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(54) **SIGNAL UNIT INCLUDING A FIELD INDICATIVE OF A ZERO-LENGTH PAYLOAD**

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(52) **U.S. Cl.**
CPC ***H04L 45/00*** (2013.01); ***H04L 1/0001*** (2013.01); ***H04L 1/16*** (2013.01)

(58) **Field of Classification Search**
CPC H04L 45/00; H04W 84/18; H04W 76/02; H04W 52/02; H04W 52/0216
USPC 370/310, 338, 311, 331, 230
See application file for complete search history.

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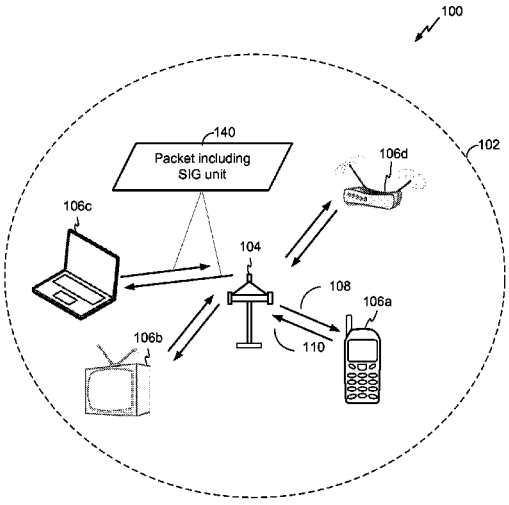
Primary Examiner — Jamal Javaid

(57) **ABSTRACT**

A method includes receiving, at a first wireless device from a second wireless device, a signal (SIG) unit including a first field. The method also includes determining whether the first field has a particular value that is indicative of a zero-length payload and decoding the SIG unit based at least in part on the determination.

16 Claims, 7 Drawing Sheets



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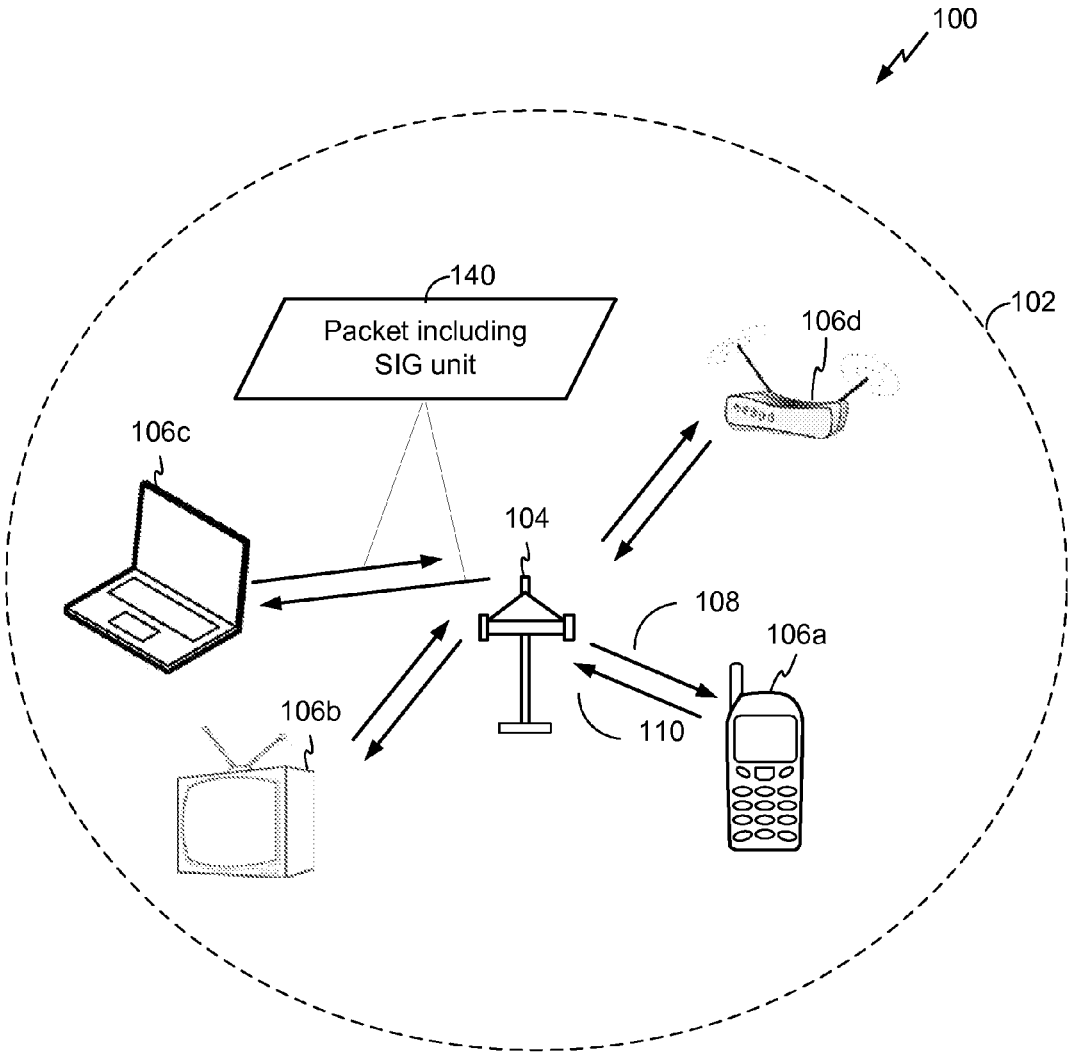
100
102
140
Packet including
SIG unit
106d
106c
104
108
106a
106b
110

FIG. 1

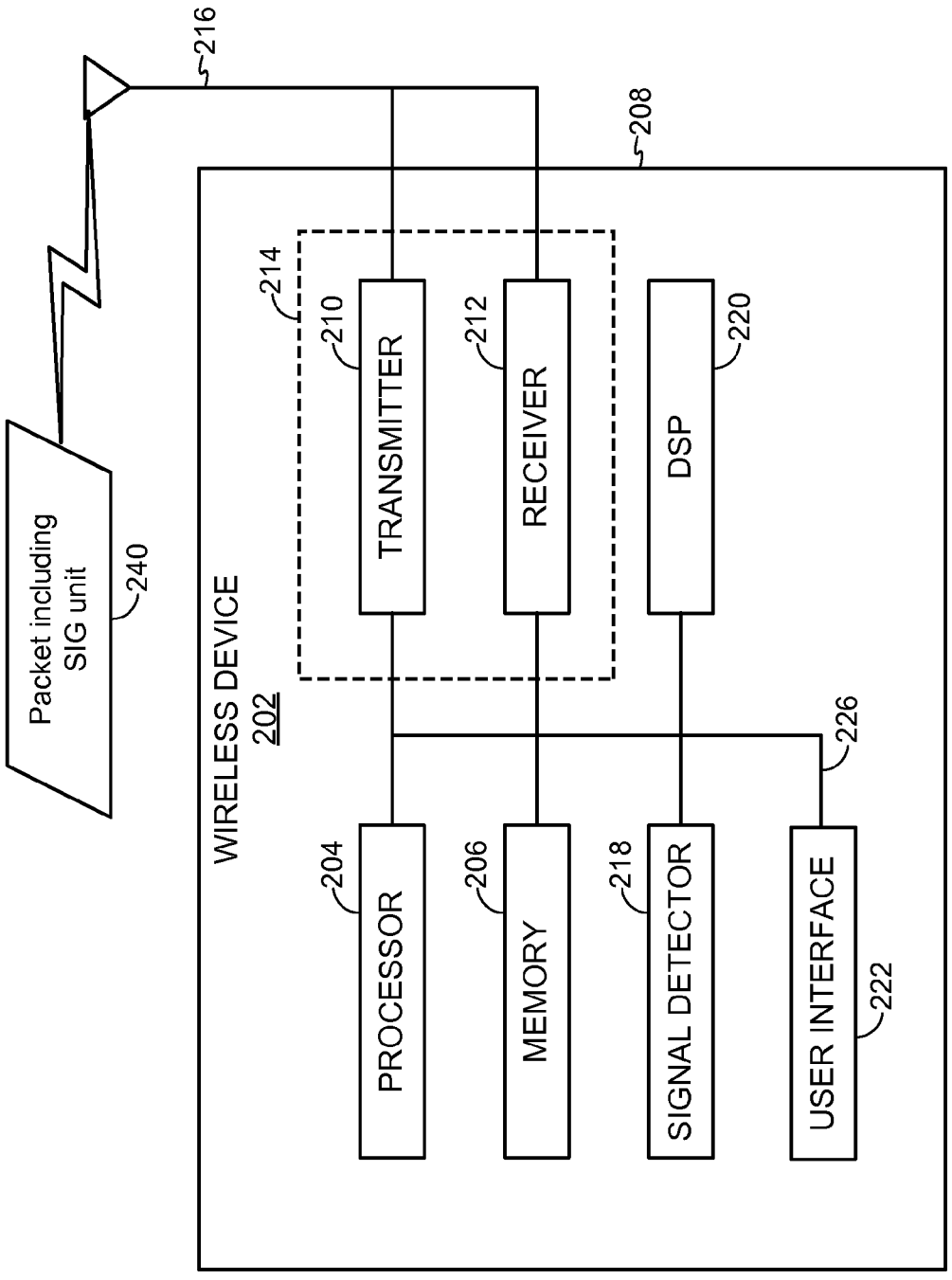
216
208
214
210
TRANSMITTER
212
RECEIVER
220
DSP
Packet including SIG unit
240
WIRELESS DEVICE
202
226
204
PROCESSOR
206
MEMORY
218
SIGNAL DETECTOR
USER INTERFACE
222

FIG. 2

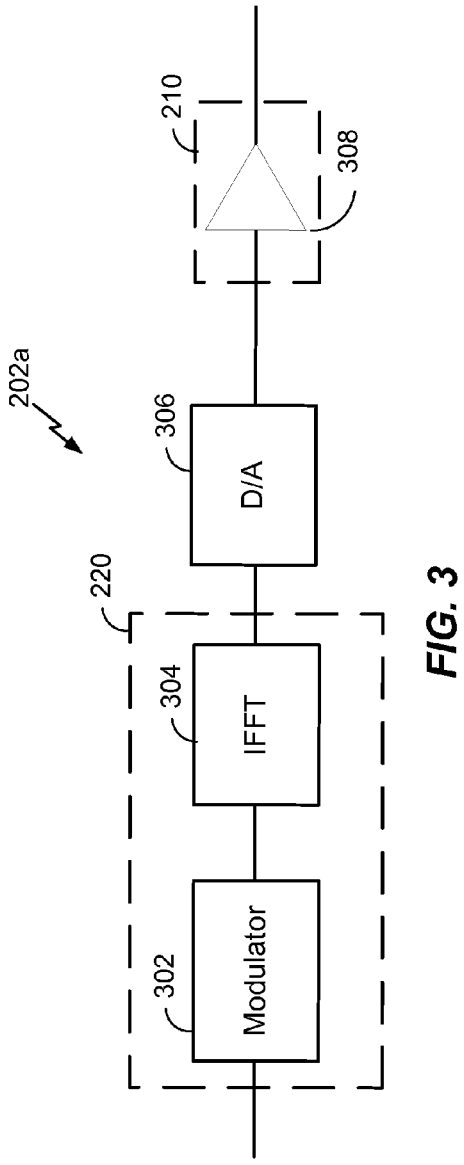
202a
210
308
306
D/A
220
304
IFFT
302
Modulator

FIG. 3

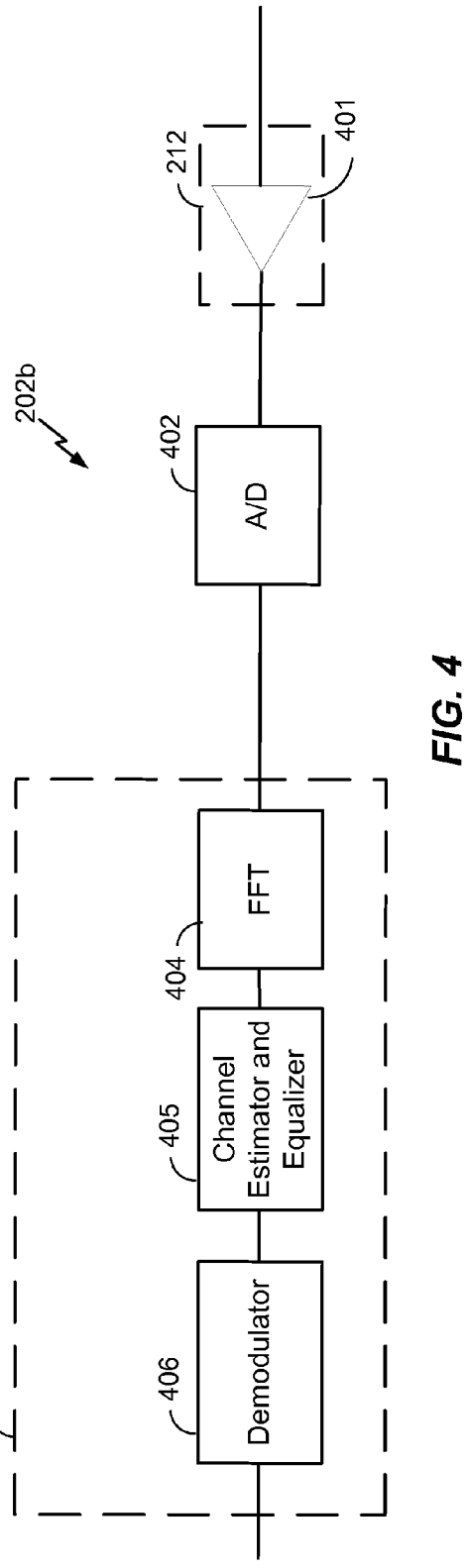
202b
212
401
402
A/D
220
404
FFT
405
Channel Estimator and Equalizer
406
Demodulator

FIG. 4

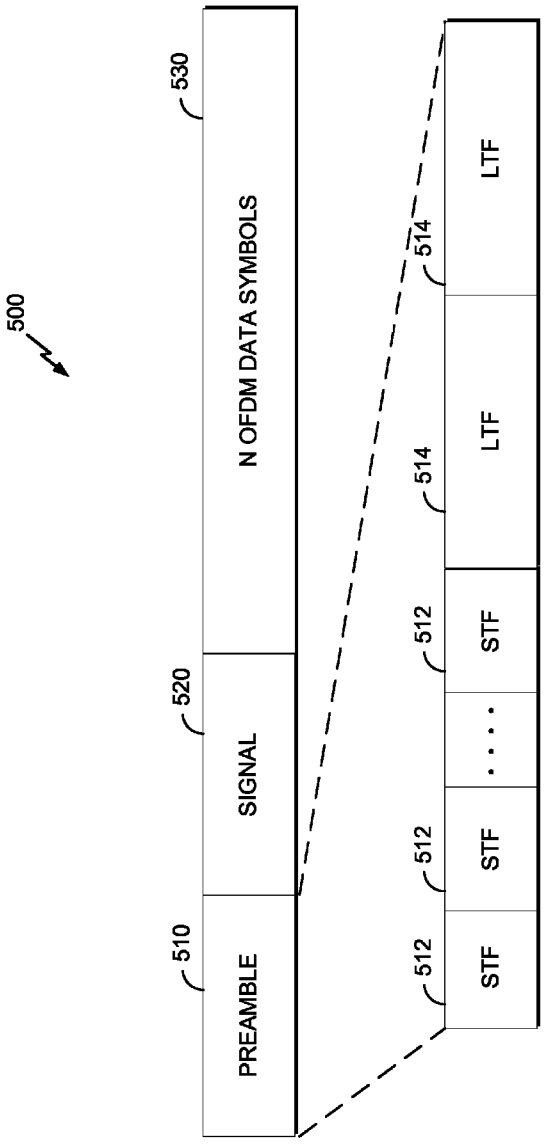
500
530
N OFDM DATA SYMBOLS
520
SIGNAL
510
PREAMBLE
514
LTF
514
LTF
512
STF
512
STF
512
STF
. . . .

FIG. 5

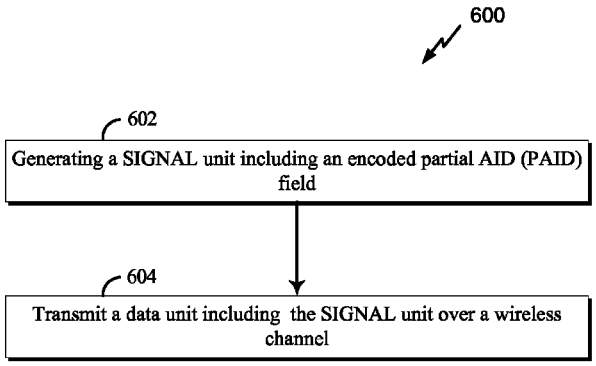
600
602
Generating a SIGNAL unit including an encoded partial AID (PAID) field
604
Transmit a data unit including the SIGNAL unit over a wireless channel

FIG. 6

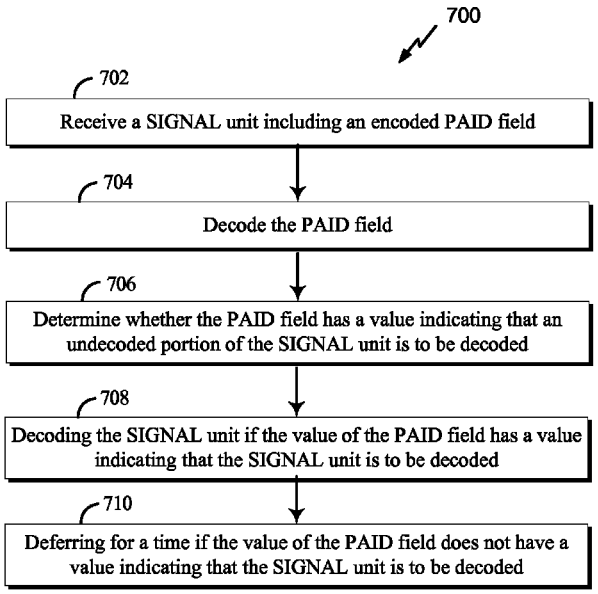
700
702
Receive a SIGNAL unit including an encoded PAID field
704
Decode the PAID field
706
Determine whether the PAID field has a value indicating that an undecoded portion of the SIGNAL unit is to be decoded
708
Decoding the SIGNAL unit if the value of the PAID field has a value indicating that the SIGNAL unit is to be decoded
710
Deferring for a time if the value of the PAID field does not have a value indicating that the SIGNAL unit is to be decoded

FIG. 7

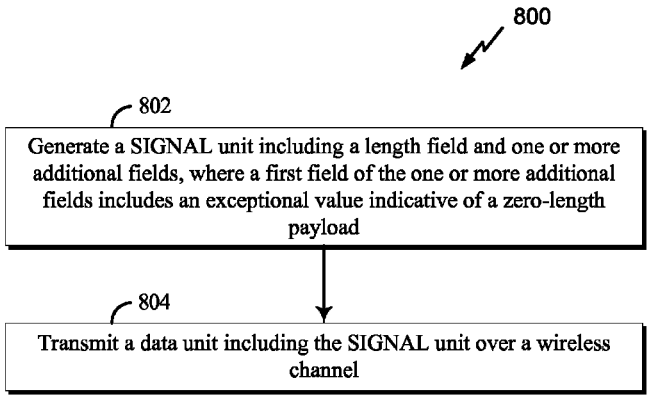
800
802
Generate a SIGNAL unit including a length field and one or more additional fields, where a first field of the one or more additional fields includes an exceptional value indicative of a zero-length payload
804
Transmit a data unit including the SIGNAL unit over a wireless channel

FIG. 8

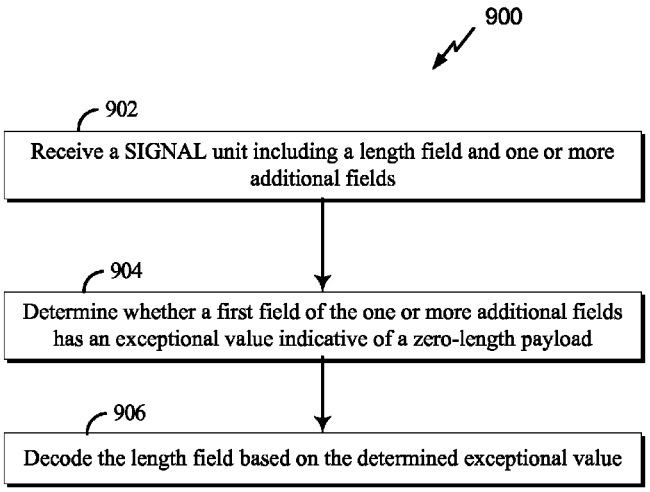
900
902
Receive a SIGNAL unit including a length field and one or more additional fields
904
Determine whether a first field of the one or more additional fields has an exceptional value indicative of a zero-length payload
906
Decode the length field based on the determined exceptional value

FIG. 9

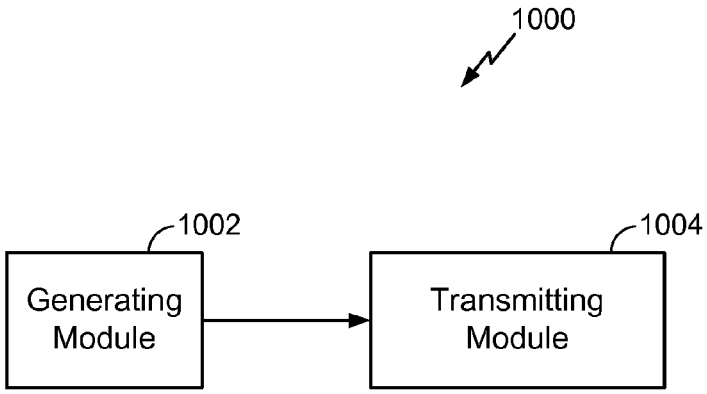
1000
1002
Generating Module
1004
Transmitting Module

FIG. 10

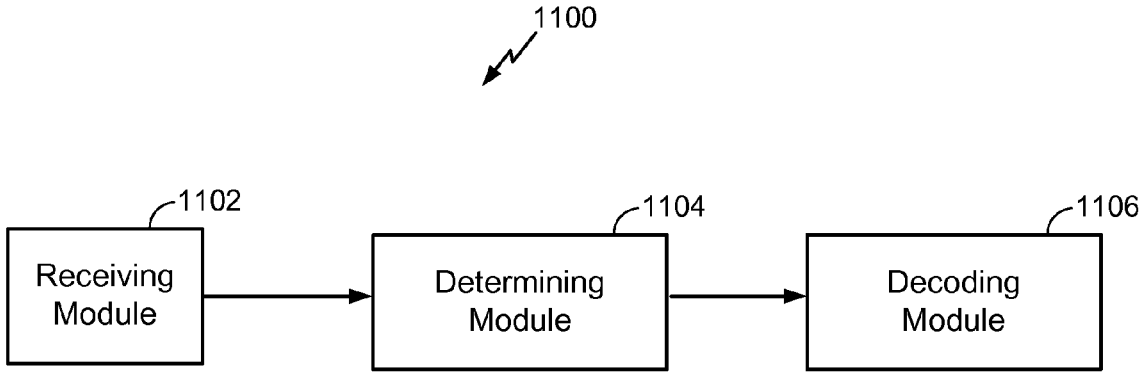
1100
1102
Receiving Module
1104
Determining Module
1106
Decoding Module

FIG. 11

SIGNAL UNIT INCLUDING A FIELD INDICATIVE OF A ZERO-LENGTH PAYLOAD

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims priority from the following commonly owned U.S. Provisional patent applications, the contents of which are expressly incorporated herein by reference in their entirety: No. 61/531,584 filed Sep. 6, 2011, No. 61/562,063 filed Nov. 21, 2011, No. 61/564,177 filed Nov. 28, 2011, No. 61/566,961 field Dec. 5, 2011, No. 61/580,616 filed Dec. 27, 2011, No. 61/585,479 filed Jan. 11, 2012, No. 61/585,573 filed Jan. 11, 2012, No. 61/670,092 filed Jul. 10, 2012, and No. 61/684,248 filed Aug. 17, 2012.

FIELD OF THE DISCLOSURE

The present disclosure relates generally to wireless communications, and more specifically to SIGNAL (SIG) units communicated via wireless networks.

BACKGROUND

In many telecommunication systems, communications networks are used to exchange messages among several interacting spatially-separated devices. Networks may be classified according to geographic scope, which could be, for example, a wide area, a metropolitan area, a local area, or a personal area. Such networks would be designated respectively as a wide area network (WAN), metropolitan area network (MAN), local area network (LAN), or personal area network (PAN). Networks also differ according to the switching/routing technique used to interconnect the various network nodes and devices (e.g. circuit switching vs. packet switching), the type of physical media employed for transmission (e.g. wired vs. wireless), and the set of communication protocols used (e.g. Internet protocol suite, SONET (Synchronous Optical Networking), Ethernet, etc.).

Wireless networks are often preferred when the network elements are mobile and thus have dynamic connectivity needs, or if the network architecture is formed in an ad hoc, rather than fixed, topology. Wireless networks employ intangible physical media in an unguided propagation mode using electromagnetic waves in the radio, microwave, infra-red, optical, etc. frequency bands. Wireless networks advantageously facilitate user mobility and rapid field deployment when compared to fixed wired networks.

The devices in a wireless network may transmit/receive information between each other. The information may include packets, which in some aspects may be referred to as data units. The packets may include overhead information (e.g., header information, packet properties, etc.) that helps in routing the packet through the network, identifying the data in the packet, processing the packet, etc., as well as data, for example user data, multimedia content, etc. as might be carried in a payload of the packet.

SUMMARY

The systems, methods, and devices of the disclosure each have several aspects, no single one of which is solely responsible for its desirable attributes. Without limiting the scope of this disclosure as expressed by the claims which follow, some features will now be discussed briefly. After considering this discussion, and particularly after reading the section entitled "Detailed Description" one will understand how the features of this disclosure provide advantages that include decreasing the overhead in transmitting payloads in data packets.

In a particular embodiment, a method includes receiving, at a first wireless device from a second wireless device, a signal (SIG) unit including a first field. The method also includes determining whether the first field has a particular value that is indicative of a zero-length payload and decoding the SIG unit based at least in part on the determination.

In another particular embodiment, a method includes generating, at a second wireless device, a SIG unit to be transmitted to a first wireless device. The SIG unit includes a first field that has a particular value indicating a zero-length payload. The method also includes transmitting the SIG unit to the first wireless device.

In another particular embodiment, an apparatus includes a receiver configured to receive a SIG unit having a first field. The apparatus also includes a processor configured to determine whether the first field has a particular value that is indicative of a zero-length payload and to decode the SIG unit based at least in part on the determination.

In another particular embodiment, an apparatus includes a processor configured to generate a SIG unit to be transmitted to a wireless device. The SIG unit includes a first field that has a particular value indicating a zero-length payload. The apparatus also includes a transmitter configured to transmit the SIG unit to the wireless device.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates an example of a wireless communication system in which aspects of the present disclosure may be employed.

FIG. **2** shows a functional block diagram of an exemplary wireless device that may be employed within the wireless communication system of FIG. **1**.

FIG. **3** shows a functional block diagram of exemplary components that may be utilized in the wireless device of FIG. **2** to transmit wireless communications.

FIG. **4** shows a functional block diagram of exemplary components that may be utilized in the wireless device of FIG. **2** to receive wireless communications.

FIG. **5** illustrates an example of a physical layer data unit.

FIG. **6** shows a flow chart of an aspect of an exemplary method for generating and transmitting a data unit.

FIG. **7** shows a flow chart of another aspect of an exemplary method for receiving and processing a data unit including a signal unit.

FIG. **8** shows a flow chart of another aspect of an exemplary method for generating and transmitting a data unit.

FIG. **9** shows a flow chart of another aspect of an exemplary method for receiving and processing a data unit including a signal unit.

FIG. **10** is a functional block diagram of another exemplary wireless device that may be employed within the wireless communication system of FIG. **1**.

FIG. **11** is a functional block diagram of yet another exemplary wireless device that may be employed within the wireless communication system of FIG. **1**.

DETAILED DESCRIPTION

Various aspects of the systems, apparatuses, and methods are described more fully hereinafter with reference to the accompanying drawings. The teachings of the disclosure may, however, be embodied in many different forms and should not be construed as limited to any specific structure or function presented throughout this disclosure. Rather, these

aspects are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the disclosure to those skilled in the art. Based on the teachings herein one skilled in the art should appreciate that the scope of the disclosure is intended to cover any aspect of the novel systems, apparatuses, and methods disclosed herein, whether implemented independently of or combined with any other aspect of the disclosure. For example, an apparatus may be implemented or a method may be practiced using any number of the aspects set forth herein. In addition, the scope of the disclosure is intended to cover such an apparatus or method which is practiced using other structure, functionality, or structure and functionality in addition to or other than the various aspects of the disclosure set forth herein. It should be understood that any aspect disclosed herein may be embodied by one or more elements of a claim.

Although particular aspects are described herein, many variations and permutations of these aspects fall within the scope of the disclosure. Although some benefits and advantages of particular aspects are mentioned, the scope of the disclosure is not intended to be limited to particular benefits, uses, or objectives. Rather, aspects of the disclosure are intended to be broadly applicable to different wireless technologies, system configurations, networks, and transmission protocols, some of which are illustrated by way of example in the figures and in the following description. The detailed description and drawings are merely illustrative of the disclosure rather than limiting, the scope of the disclosure being defined by the appended claims and equivalents thereof.

Wireless network technologies may include various types of wireless local area networks (WLANs). A WLAN may be used to interconnect nearby devices together, employing widely used networking protocols. The various aspects described herein may apply to any communication standard, such as WiFi or, more generally, any member of the IEEE 802.11 family of wireless protocols. For example, the various aspects described herein may be used as part of the IEEE 802.11ah protocol, which uses sub-1 GHz bands.

In some aspects, wireless signals in a sub-gigahertz band may be transmitted according to the 802.11ah protocol using orthogonal frequency-division multiplexing (OFDM), direct-sequence spread spectrum (DSSS) communications, a combination of OFDM and DSSS communications, or other schemes. Implementations of the 802.11ah protocol may be used for sensors, metering, and smart grid networks. Advantageously, aspects of certain devices implementing the 802.11ah protocol may consume less power than devices implementing other wireless protocols, and/or may be used to transmit wireless signals across a relatively long range, for example about one kilometer or longer.

In some implementations, a WLAN includes various devices which are the components that access the wireless network. For example, there may be two types of devices: access points ("APs") and clients (also referred to as stations, or "STAs"). In general, an AP serves as a hub or base station for the WLAN, and an STA serves as a user of the WLAN. For example, an STA may be a laptop computer, a personal digital assistant (PDA), a mobile phone, etc. In an example, an STA connects to an AP via a WiFi (e.g., IEEE 802.11 protocol such as 802.11ah) compliant wireless link to obtain general connectivity to the Internet or to other wide area networks. In some implementations an STA may also be used as an AP.

An access point ("AP") may also include, be implemented as, or known as a NodeB, Radio Network Controller ("RNC"), eNodeB, Base Station Controller ("BSC"), Base Transceiver Station ("BTS"), Base Station ("BS"), Transceiver Function ("TF"), Radio Router, Radio Transceiver, or some other terminology.

A station ("STA") may also include, be implemented as, or known as an access terminal ("AT"), a subscriber station, a subscriber unit, a mobile station, a remote station, a remote terminal, a user terminal, a user agent, a user device, user equipment, or some other terminology. In some implementations an access terminal may include a cellular telephone, a cordless telephone, a Session Initiation Protocol ("SIP") phone, a wireless local loop ("WLL") station, a personal digital assistant ("PDA"), a handheld device having wireless connection capability, or some other suitable processing device connected to a wireless modem. Accordingly, one or more aspects taught herein may be incorporated into a phone (e.g., a cellular phone or smartphone), a computer (e.g., a laptop), a portable communication device, a headset, a portable computing device (e.g., a personal data assistant), an entertainment device (e.g., a music or video device, or a satellite radio), a gaming device or system, a global positioning system device, or any other suitable device that is configured to communicate via a wireless medium.

As discussed above, certain of the devices described herein may implement the 802.11ah standard, for example. Such devices, whether used as an STA or AP or other device, may be used for smart metering or in a smart grid network. Such devices may provide sensor applications or be used in home automation. The devices may instead or in addition be used in a healthcare context, for example for personal healthcare. They may also be used for surveillance, to enable extended-range Internet connectivity (e.g. for use with hotspots), or to implement machine-to-machine communications.

FIG. **1** illustrates an example of a wireless communication system **100** in which aspects of the present disclosure may be employed. The wireless communication system **100** may operate pursuant to a wireless standard, for example the 802.11ah standard. The wireless communication system **100** may include an AP **104**, which communicates with STAs **106**.

A variety of processes and methods may be used for transmissions in the wireless communication system **100** between the AP **104** and the STAs **106**. For example, signals may be sent and received between the AP **104** and the STAs **106** in accordance with OFDM/OFDMA techniques. If this is the case, the wireless communication system **100** may be referred to as an OFDM/OFDMA system. Alternatively, signals may be sent and received between the AP **104** and the STAs **106** in accordance with CDMA techniques. If this is the case, the wireless communication system **100** may be referred to as a CDMA system.

A communication link that facilitates transmission from the AP **104** to one or more of the STAs **106** may be referred to as a downlink (DL) **108**, and a communication link that facilitates transmission from one or more of the STAs **106** to the AP **104** may be referred to as an uplink (UL) **110**. Alternatively, a downlink **108** may be referred to as a forward link or a forward channel, and an uplink **110** may be referred to as a reverse link or a reverse channel.

The AP **104** may act as a base station and provide wireless communication coverage in a basic service area (BSA) **102**. The AP **104** along with the STAs **106** associated with the AP **104** and that use the AP **104** for communication may be referred to as a basic service set (BSS). It should be noted that the wireless communication system **100** may not have a central AP **104**, but rather may function as a peer-to-peer network between the STAs **106**. Accordingly, the functions of the AP **104** described herein may alternatively be performed by one or more of the STAs **106**.

As further described herein, packets (e.g., illustrative packet **140**) (alternately referred to herein as data units or frames) transmitted between the AP **104** and the STAs **106** may include a SIGNAL (SIG) unit (alternately referred to herein as a SIG field). For example, the SIG unit may be included in a physical layer (PHY) preamble of a packet. The SIG unit may include control information that can be used to decode the packet or a data payload thereof. In a particular embodiment, a length field of the SIG unit may indicate a length of the packet or data payload thereof. The length field may have a fixed size, such as nine bits. However, the unit of measurement represented by the length field may vary. For example, when data aggregation is not in use (e.g., indicated by an aggregation field of the SIG unit having a first value), the length field may represent a number of bytes. Since 2^9=512, the SIG unit may be able to indicate packet sizes ranging from 0 to 511 bytes. When data aggregation is in use (e.g., indicated by the aggregation field of the SIG unit having a second value), the length field may represent a number of symbols and may thus be able to represent sizes larger than 511 bytes.

In a particular embodiment, as further described herein, one or more fields of a SIG unit may support the use of "exceptional" values to indicate alternative data formats, payload lengths, and types. For example, a particular value of a particular field of the SIG unit may indicate that another field of the SIG unit is to be interpreted unconventionally, that the SIG unit is part of a packet that has a zero-length payload, or that the SIG unit is part of a particular type of packet. For example, a particular value of a modulation and coding scheme (MCS) field may indicate that the SIG unit is part of an acknowledgement (ACK) packet that has a zero-length payload (e.g., an ACK packet that is represented entirely by PHY data).

FIG. **2** illustrates various components that may be utilized in a wireless device **202** that may be employed within the wireless communication system **100**. The wireless device **202** is an example of a device that may be configured to implement the various methods described herein. For example, the wireless device **202** may include the AP **104** or one of the STAs **106**.

The wireless device **202** may include a processor **204** which controls operation of the wireless device **202**. The processor **204** may also be referred to as a central processing unit (CPU). Memory **206**, which may include both read-only memory (ROM) and random access memory (RAM), provides instructions and data to the processor **204**. A portion of the memory **206** may also include non-volatile random access memory (NVRAM). The processor **204** typically performs logical and arithmetic operations based on program instructions stored within the memory **206**. The instructions in the memory **206** may be executable to implement the methods described herein.

The processor **204** may include or be a component of a processing system implemented with one or more processors. The one or more processors may be implemented with any combination of general-purpose microprocessors, microcontrollers, digital signal processors (DSPs), field programmable gate array (FPGAs), programmable logic devices (PLDs), controllers, state machines, gated logic, discrete hardware components, dedicated hardware finite state machines, or any other suitable entities that can perform calculations or other manipulations of information.

The processing system may also include machine-readable media for storing software. Software shall be construed broadly to mean any type of instructions, whether referred to as software, firmware, middleware, microcode, hardware description language, or otherwise. Instructions may include code (e.g., in source code format, binary code format, executable code format, or any other suitable format of code). The instructions, when executed by the one or more processors, cause the processing system to perform the various functions described herein.

The wireless device **202** may also include a housing **208** that may include a transmitter **210** and a receiver **212** to allow transmission and reception of data between the wireless device **202** and a remote location. The transmitter **210** and receiver **212** may be combined into a transceiver **214**. An antenna **216** may be attached to the housing **208** and electrically coupled to the transceiver **214**. The wireless device **202** may also include (not shown) multiple transmitters, multiple receivers, multiple transceivers, and/or multiple antennas. As further described herein, the transmitter **210** may be means for transmitting a SIG unit and the receiver **212** may be means for receiving a SIG unit.

The wireless device **202** may also include a signal detector **218** that may be used in an effort to detect and quantify the level of signals received by the transceiver **214**. The signal detector **218** may detect characteristics of signals, such as total energy, energy per subcarrier per symbol, and power spectral density. The wireless device **202** may also include a digital signal processor (DSP) **220** for use in processing signals. The DSP **220** may be configured to generate a data unit for transmission. In some aspects, the data unit may include a physical layer data unit (PPDU). In some aspects, the PPDU is referred to as a packet. As further described herein, one or more of the processor **204**, the signal detector **218**, and the DSP **220** may be means for generating a SIG unit, means for interpreting a length field of a SIG unit, means for determining whether a field of the SIG unit has a value indicating a zero-length payload, and/or means for decoding the SIG unit based on the determination.

The wireless device **202** may further include a user interface **222** in some aspects. The user interface **222** may include a keypad, a microphone, a speaker, and/or a display. The user interface **222** may include any element or component that conveys information to a user of the wireless device **202** and/or receives input from the user.

The various components of the wireless device **202** may be coupled together by a bus system **226**. The bus system **226** may include a data bus, for example, as well as a power bus, a control signal bus, and a status signal bus in addition to the data bus. Those of skill in the art will appreciate the components of the wireless device **202** may be coupled together or accept or provide inputs to each other using some other mechanism.

Although a number of separate components are illustrated in FIG. **2**, those of skill in the art will recognize that one or more of the components may be combined or commonly implemented. For example, the processor **204** may be used to implement not only the functionality described above with respect to the processor **204**, but also to implement the functionality described above with respect to the signal detector **218** and/or the DSP **220**. Further, each of the components illustrated in FIG. **2** may be implemented using a plurality of separate elements.

As discussed above, the wireless device **202** may include an AP **104** or an STA **106**, and may be used to transmit and/or receive communications. For example, the wireless device **202** may communicate a packet **240** that includes a SIG unit. As further described herein, the packet **240** may include a SIG unit having a length field that can be interpreted in multiple ways based on the value of another field in the SIG unit. For example, the length field may be interpreted as a number of

bytes or a number of symbols based on the value of an aggregation field. Alternately, or in addition, the presence of a particular value in a particular field of the SIG unit may indicate that the packet **240** has a zero-length payload (e.g., is a short ACK that is entirely represented by PHY data).

FIG. **3** illustrates various components that may be utilized in the wireless device **202** to transmit wireless communications. The components illustrated in FIG. **3** may be used, for example, to transmit OFDM communications. In some aspects, the components illustrated in FIG. **3** are used to transmit data units with SIGNAL units (e.g., the packet **240** of FIG. **2**) in various communication modes, as will be discussed in additional detail below. For ease of reference, the wireless device **202** configured with the components illustrated in FIG. **3** is hereinafter referred to as a wireless device **202***a*.

The wireless device **202***a* may include a modulator **302** configured to modulate bits for transmission. For example, the modulator **302** may determine a plurality of symbols from bits received from the processor **204** or the user interface **222**, for example by mapping bits to a plurality of symbols according to a constellation. The bits may correspond to user data or to control information. In some aspects, the bits are received in codewords. In one aspect, the modulator **302** includes a QAM (quadrature amplitude modulation) modulator, for example a 16-QAM modulator or a 64-QAM modulator. In other aspects, the modulator **302** includes a binary phase-shift keying (BPSK) modulator or a quadrature phase-shift keying (QPSK) modulator.

The wireless device **202***a* may further include a transform module **304** configured to convert symbols or otherwise modulated bits from the modulator **302** into a time domain. In FIG. **3**, the transform module **304** is illustrated as being implemented by an inverse fast Fourier transform (IFFT) module. In some implementations, there may be multiple transform modules (not shown) that transform units of data of different sizes.

In FIG. **3**, the modulator **302** and the transform module **304** are illustrated as being implemented in the DSP **220**. In some aspects, however, one or both of the modulator **302** and the transform module **304** are implemented in the processor **204** or in another element of the wireless device **202**.

As discussed above, the DSP **220** may be configured to generate a data unit for transmission. In some aspects, the modulator **302** and the transform module **304** may be configured to generate a data unit including a plurality of fields including control information and a plurality of data symbols. The fields including the control information may include one or more training fields, for example, and one or more signal (SIG) fields. Each of the training fields may include a known sequence of bits or symbols. Each of the SIG fields may include information about the data unit, for example a description of a length or data rate of the data unit.

Returning to the description of FIG. **3**, the wireless device **202***a* may further include a digital to analog converter (DAC, designated "D/A" in FIG. **3**) **306** configured to convert the output of the transform module into an analog signal. For example, the time-domain output of the transform module **304** may be converted to a baseband OFDM signal by the digital to analog converter **306**. The digital to analog converter **306** may be implemented in the processor **204** or in another element of the wireless device **202**. In some aspects, the digital to analog converter **306** is implemented in the transceiver **214** or in a data transmit processor.

The analog signal may be wirelessly transmitted by the transmitter **210**. The analog signal may be further processed before being transmitted by the transmitter **210**, for example by being filtered or by being upconverted to an intermediate or carrier frequency. In the aspect illustrated in FIG. **3**, the transmitter **210** includes a transmit amplifier **308**. Prior to being transmitted, the analog signal may be amplified by the transmit amplifier **308**. In some aspects, the amplifier **308** includes a low noise amplifier (LNA).

The transmitter **210** is configured to transmit one or more packets or data units in a wireless signal based on the analog signal. The data units may be generated using the processor **204** and/or the DSP **220**, for example using the modulator **302** and the transform module **304** as discussed above. Data units that may be generated and transmitted as discussed above are described in additional detail below with respect to FIGS. **5-11**.

FIG. **4** illustrates various components that may be utilized in the wireless device **202** to receive wireless communications. The components illustrated in FIG. **4** may be used, for example, to receive OFDM communications. In some aspects, the components illustrated in FIG. **4** are used to receive data units that include one or more SIGNAL units (e.g., the packet **240** of FIG. **2**), as will be discussed in additional detail below. For example, the components illustrated in FIG. **4** may be used to receive data units transmitted by the components discussed above with respect to FIG. **3**. For ease of reference, the wireless device **202** configured with the components illustrated in FIG. **4** is hereinafter referred to as a wireless device **202***b*.

The receiver **212** is configured to receive one or more packets or data units in a wireless signal. Data units that may be received and decoded or otherwise processed as discussed below are described in additional detail with respect to FIGS. **5-11**.

In the aspect illustrated in FIG. **4**, the receiver **212** includes a receive amplifier **401**. The receive amplifier **401** may be configured to amplify the wireless signal received by the receiver **212**. In some aspects, the receiver **212** is configured to adjust the gain of the receive amplifier **401** using an automatic gain control (AGC) procedure. In some aspects, the automatic gain control uses information in one or more received training fields, such as a received short training field (STF) for example, to adjust the gain. Those having ordinary skill in the art will understand methods for performing AGC. In some aspects, the amplifier **401** includes a LNA.

The wireless device **202***b* may include an analog to digital converter (ADC, designated "A/D" in FIG. **4**) **402** configured to convert the amplified wireless signal from the receiver **212** into a digital representation thereof. Further to being amplified, the wireless signal may be processed before being converted by the analog to digital converter **402**, for example by being filtered or by being downconverted to an intermediate or baseband frequency. The analog to digital converter **402** may be implemented in the processor **204** or in another element of the wireless device **202**. In some aspects, the analog to digital converter **402** is implemented in the transceiver **214** or in a data receive processor.

The wireless device **202***b* may further include a transform module **404** configured to convert the representation the wireless signal into a frequency spectrum. In FIG. **4**, the transform module **404** is illustrated as being implemented by a fast Fourier transform (FFT) module. The transform module **404** may be programmable, and may be configured to perform FFT with different configurations. In one aspect, for example, the transform module **404** may be configured to perform either a 32-point FFT or a 64-point FFT. In some aspects, the transform module **404** may identify a symbol for each point that it uses.

The wireless device **202***b* may further include a channel estimator and equalizer **405** configured to form an estimate of

the channel over which the data unit is received, and to remove certain effects of the channel based on the channel estimate. For example, the channel estimator may be configured to approximate a function of the channel, and the channel equalizer may be configured to apply an inverse of that function to the data in the frequency spectrum.

In some aspects, the channel estimator and equalizer **405** uses information in one or more received training fields, such as a long training field (LTF) for example, to estimate the channel. The channel estimate may be formed based on one or more LTFs received at the beginning of the data unit. This channel estimate may thereafter be used to equalize data symbols that follow the one or more LTFs. After a certain period of time or after a certain number of data symbols, one or more additional LTFs may be received in the data unit. The channel estimate may be updated or a new estimate formed using the additional LTFs. This new or update channel estimate may be used to equalize data symbols that follow the additional LTFs. In some aspects, the new or updated channel estimate is used to re-equalize data symbols preceding the additional LTFs. Those having ordinary skill in the art will understand methods for forming a channel estimate.

The wireless device **202***b* may further include a demodulator **406** configured to demodulate the equalized data. For example, the demodulator **406** may determine a plurality of bits from symbols output by the transform module **404** and the channel estimator and equalizer **405**, for example by reversing a mapping of bits to a symbol in a constellation. The bits may be processed or evaluated by the processor **204**, or used to display or otherwise output information to the user interface **222**. In this way, data and/or information may be decoded. In some aspects, the bits correspond to codewords. In one aspect, the demodulator **406** includes a QAM (quadrature amplitude modulation) demodulator, for example a 16-QAM demodulator or a 64-QAM demodulator. In other aspects, the demodulator **406** includes a binary phase-shift keying (BPSK) demodulator or a quadrature phase-shift keying (QPSK) demodulator.

In FIG. **4**, the transform module **404**, the channel estimator and equalizer **405**, and the demodulator **406** are illustrated as being implemented in the DSP **220**. In some aspects, however, one or more of the transform module **404**, the channel estimator and equalizer **405**, and the demodulator **406** are implemented in the processor **204** or in another element of the wireless device **202**.

As discussed above, the wireless signal received at the receiver **212** includes one or more data units. Using the functions or components described above, the data units or data symbols therein may be decoded evaluated or otherwise evaluated or processed. For example, the processor **204** and/or the DSP **220** may be used to decode data symbols in the data units using the transform module **404**, the channel estimator and equalizer **405**, and the demodulator **406**.

Data units exchanged by the AP **104** and the STA **106** may include control information or data, as discussed above. At the physical (PHY) layer, these data units may be referred to as physical layer protocol data units (PPDUs). In some aspects, a PPDU may be referred to as a packet or physical layer packet. Each PPDU may include a preamble and a payload. The preamble may include training fields and a SIG field. The payload may include a Media Access Control (MAC) header or data for other layers, and/or user data, for example. In various embodiments, data units can include Mac Protocol Data Units (MPDU) and/or Aggregated Mac Protocol Data Units (A-MPDU). The payload may be transmitted using one or more data symbols. The systems, methods, and devices herein may utilize data units with training fields whose peak-to-power ratio has been minimized.

The data units may be transmitted, for example, in a 1 MHz mode or a 2 MHz mode. The preamble may be common for a 1 MHz normal mode and for a 1 MHz 2× repetition mode. In a 2 MHz mode, the SIG field may span 52 data tones. In some embodiments, a SIG field may be replicated every 2 MHz for transmissions greater than 2 MHz. In addition, for transmission greater than 2 MHz, there may be 2 SIG-A fields and 1 SIG-B field for MU mode. In some embodiments, in a 1 MHz mode there may be 6 SIG A fields. In a 1 MHz mode, the SIG field may span 24 data tones. In some embodiments, the 2 MHz PHY transmission is an OFDM based waveform consisting of 64 tones (52 data tones, 4 pilot tones, 7 guard tones, and 1 DC tone). The tone spacing for other bandwidth modes may be the same as the tone spacing for a 2 MHz mode. In some embodiments, a 1 MHz mode includes 32 tones (24 data tones, 2 pilot tones, 5 guard tones, and 1 DC tone).

FIG. **5** illustrates an example of a data unit **500**. The data unit **500** may include a PPDU for use with the wireless device **202**. In an embodiment, the data unit **500** may be used by legacy devices or devices implementing a legacy standard or downclocked version thereof.

The data unit **500** includes a preamble **510**. The preamble **510** may include a variable number of repeating STF **512** symbols, and one or more LTF **514** symbols. In one implementation 10 repeated STF **512** symbols may be sent followed by two LTF **512** symbols. The STF **512** may be used by the receiver **212** to perform automatic gain control to adjust the gain of the receive amplifier **401**, as discussed above. Furthermore, the STF **512** sequence may be used by the receiver **212** for packet detection, rough timing, and other settings. The LTF **514** may be used by the channel estimator and equalizer **405** to form an estimate of the channel over which the data unit **500** is received.

Following the preamble **510** in the data unit **500** is a SIGNAL unit **520**. The SIGNAL **520** unit may be represented using OFDM and may include information relating to the transmission rate, the length of the data unit **500**, and the like. The data unit **500** additionally includes a variable number of data symbols **530**, such as OFDM data symbols. In an embodiment, the preamble **510** can include the SIGNAL unit **520**. In an embodiment, one or more of the data symbols **530** can be a payload.

When the data unit **500** is received at the wireless device **202***b*, the size of the data unit **500** including the LTFs **514** may be computed based on the SIGNAL unit **520**, and the STF **512** may be used by the receiver **212** to adjust the gain of the receive amplifier **401**. Further, a LTF may be used by the channel estimator and equalizer **405** to form an estimate of the channel over which the data unit **500** is received. The channel estimate may be used by the DSP **220** to decode the plurality of data symbols **530** that follow the preamble **510**.

The data unit **500** illustrated in FIG. **5** is only an example of a data unit that may be used in the system **100** and/or with the wireless device **202**. Those having ordinary skill in the art will appreciate that a greater or fewer number of the STFs **412** or LTFs **514** and/or the data symbols **530** may be included in the data unit **500**. In addition, one or more symbols or fields may be included in the data unit **500** that are not illustrated in FIG. **5**, and one or more of the illustrated fields or symbols may be omitted.

When using OFDM, a number of orthogonal subcarriers of the frequency band may be used. The number of subcarriers that are used may depend on a variety of considerations including the available frequency bands for use, bandwidth and any associated regulatory constraints. The number of

subcarriers used is correlated to the size of an FFT module as each modulated subcarrier is an input to an IFFT module to create the OFDM signal to be transmitted. As such, in some implementations a larger FFT size (e.g., 64, 128, 256, or 512) may, corresponding to transmitting data using more subcarriers, be desired to achieve a larger bandwidth. In other implementations, a smaller FFT size may be used for transmitting data in a narrow bandwidth. The number of subcarriers, and therefore FFT size, may be chosen so as to comply with regulatory domains with certain bandwidth restrictions. For example, an FFT size of 32 may be provided for certain implementations (e.g., for down clocked implementations), and provided for use for 802.11ah. As such, the wireless device **202***a* may include several transform modules **304**, each implemented as an FFT or IFFT module, each of a different size so as to comply with the number of subcarriers specified to be used. At least one of the transform modules **304** may be a 32-point size IFFT or FFT module according to certain aspects described herein. In an embodiment, the transform module **304** may be configured to selectively perform FFT in a plurality of different sizes based on a detected FFT mode. In an aspect, a multi-mode transform module may include a plurality of FFT modules, each configured to use different FFT sizes, the output of each of which may be selected based on a detected FFT mode.

As discussed above with respect to FIGS. **2** and **3**, the wireless device **202***a* can be configured to operate in various FFT modes. In various embodiments, the wireless device **202***a* can be configured to use a 64-point FFT size in conjunction with a higher-bandwidth channel than the 32-point FFT channel. For example, the 64-point FFT channel can have twice the bandwidth of the 32-point FFT channel. In an embodiment, the transform module **304** can be configured to use a 64-point FFT size in conjunction with a 2 MHz channel, and the transform module **304** can be configured to use a 32-point FFT channel can be a 1 MHz channel. In an embodiment, the transform module **304** can be configured to selectively use a plurality of different FFT sizes. In another embodiment, a plurality of different IFFTs can each be configured to use a different FFT size, the output of which can be selectively routed to the DAC **306**.

In some embodiments, the data unit **500** may include a Partial air identifier (AID) or PAID field. The PAID field includes a partial identifier for one or more receivers or STAs **106**. The PAID field may be used by each STA **106** as an early indicator of whether the STA **106** should receive and decode the remainder of the data unit **500**. For example, if the PAID field indicates that the data unit **500** is not intended for a particular STA **106**, that STA **106** may discontinue processing the data unit **500** in order to save power.

In some embodiments, the PAID field includes a unique identification of the STA **106**, such as a full local identifier (e.g., an AID) of the STA **106**. In some embodiments, the PAID field includes a partial local identifier of the STA **106**, such as a portion of the AID, for example, some number of least significant bits (LSBs) of the AID. In some embodiments, the PAID field includes a partial local identifier of the STA **106** and a partial local identifier of the associated BSS or the AP **104**.

In some embodiments, the PAID field is not explicitly transmitted, but is encoded in another field, such as a cyclic redundancy check (CRC) field. For example, a CRC may be calculated with the PAID field and other fields of the data unit **500** which are transmitted. The STA **106** receives the transmitted fields and the CRC field. The STA **106** then calculates a CRC based on the received fields and the PAID field which indicates that the STA **106** should continue processing the data unit **500**. If the CRC calculated by the STA **106** matches the CRC received, the STA **106** continues processing the data unit **500**.

In some embodiments, the data unit **500** includes multiple sets of parameters. A first set of parameters may include parameters used to determine how long the STA **106** is in a power down mode if the data unit **500** is not intended for the STA **106**. A second set of parameters may include other parameters of the data unit **500**, such as those discussed below. The PAID field may be included in the second set. In some embodiments, each of the sets of parameters is covered by an independent CRC specific to that set. Each STA **106** determines based on the PAID field whether the data unit **500** is to be decoded. If the data unit **500** is not to be decoded, the STA **106** defers for a time based on the information in the first set of parameters. In some embodiments, the CRCs are in the SIG field. In some embodiments, the CRC of the second set of parameters is in the service field after the preamble, for example if the data unit **500** is for non-AMPDU.

In some embodiments, the PAID field is in the service field. In such embodiments, the PAID field may be sent with the same MCS as the data in the SIG field. In some embodiments, the PAID field may immediately precede the MAC header.

In some embodiments, the data unit **500** includes a random seed for use by the STA **106** to descramble the data. In some embodiments, at least a portion of the PAID field may also be the seed. In some embodiments, the STA **106** may recognize multiple, for example, consecutive, PAID fields as new seeds for retransmissions.

In some embodiments, the data unit **500** includes no service field. In such embodiments the bandwidth may be indicated, for example, in the SIG field or in the MAC header. Similarly, a CRC may be included, for example, in the SIG field or in the MAC header. Additionally, or alternatively, the random seed may be included, for example, in the SIG field or in the MAC header. In some embodiments, the random seed may also be included in the PAID field.

In some embodiments, the PAID field is scrambled with the data in the SIG field and the scrambled sequence is covered by a CRC. Alternatively, the PAID field may be appended to the SIG field and the set is covered by a CRC.

In some embodiments, the PAID field is not static over multiple transmissions to a STA **106**. For example, the PAID field may change each transmission or may change after each number of transmissions. The PAID field may be changed according to an algorithm common to both the transmitting device and the receiving STA **106**. For example, the next in a series of numbers can be used. In some embodiments, the next PAID field value is equal to the previous PAID field value plus one. In some embodiments, the algorithm includes generating the PAID field based in part on the timing synchronization function (TSF) or a hash of the TSF of the network. The calculations of the PAID field may occur, for example, every second, every 2, 3, 4, 5, or other number of seconds, every minute, every 2, 3, 4, 5, or other number of minutes. Accordingly, errors due to TSF misalignment will be rare.

In some embodiments, the receiving STA **106** communicates to the transmitting device the PAID field value or an indication of the PAID field value to use for a next transmission. For example, the next PAID field value or an indication of the next PAID field value may be included in an ACK sent in response to a received transmission from the transmitting device.

For example, in a first data unit, the AP **104** uses a default PAID field value, to which the STA **106** responds by decoding the first data unit. The STA **106** sends an ACK to acknowledge receipt of the first data unit. In the ACK communication, the

STA **106** indicates a next PAID field value. Subsequently, in a second data unit, the AP **104** uses the next PAID field value, to which the STA **106** responds by decoding the second data unit.

The default PAID field value may be, for example, a broadcast PAID field value or may be, for example, a PAID field value associated with the particular STA **106** to which the first and second data units are intended. The next PAID field value may, for example, be a next in a series of numbers or may, for example, be a hash of at least a portion of the first data unit, such as the data of the first data unit.

In some embodiments, if the AP **104** does not receive the ACK, the AP **104** may transmit the second data unit using the default PAID field value or the latest PAID field value for which an ACK was received. Accordingly, the STA **106** may be configured to decode data units which include any of multiple PAID field values. For example, the STA **106** may be configured to decode data units which include any of the default PAID field value, the PAID field value for the latest received and decoded data unit, and the PAID field value indicated in the latest ACK transmitted by the STA **106**. In such embodiments, the AP **104** may be configured to select one of the multiple PAID field values for the STA **106**. Such selection, may, for example, be random or pseudorandom.

In some embodiments, the PAID field is assigned by the AP **104** with, for example, a management exchange. For example, the PAID field may be reassigned periodically. In some embodiments, the STA **106** may request or assign a new PAID field for a next transmission from the AP **104**. For example, if a STA **106** decodes multiple data units which are not intended for that STA **106**, the STA **106** may request or designate a new PAID field value.

In some systems, unicast packet filtering is possible through MAC address. In such systems, the PAID field may be useful in enhancing packet filtering based on packet content.

In some embodiments, the PAID field may identify a type of the data unit. In some embodiments, the PAID field may additionally identify the content of the data unit. For example, if the data unit includes a traffic indication map (TIM) for a group of STAs, the PAID field may identify the group of STAs the data unit is intended for. In some embodiments, certain values of the PAID field may be used to indicate that the data unit is a beacon and to identify the beacon change sequence number. If the STA is already up to date the STA can ignore the remainder of the data unit after processing the PAID field.

In an embodiment, for 64-point FFT signals, the data unit **500** can include a 240 μs preamble **510**. The preamble **510** can include a single 2-symbol STF **512**, a single 2-symbol LTF **514**, and a 2-symbol SIGNAL unit **520**. The SIGNAL unit **520** can include one or more of the fields shown below in Table 1. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length. In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 1. In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 1. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 1 in the order shown in Table 1. In some embodiments, at least a portion of the information of multiple fields shown in Table 1 is included in a single field. For example, the first and second fields of Table 1 may be collapsed into a single field including the information of both the first and second fields.

TABLE 1

Field of SIG-A (64-Point FFT)	Bits
MCS	4
Num SS	2
SGI	1
Length	12
Aggregation	1
BW	2
Coding	1
AID	12
STBC	1
Smoothing	1
Reserved	1
CRC	4
Tail	6
Total	48

In the aspect shown in Table 1, the SIGNAL unit **520** can include an "MCS" field indicating the modulation coding scheme (MCS) used. The "MCS" field can be 4-bits long. In an embodiment, the "MCS" field may indicate that, for example, quadrature phase-shift keying (QPSK) is used. The SIGNAL unit **520** can further include a "Num SS" field indicating the number of spatial streams used. The "Num SS" field can be 2-bits long. The SIGNAL unit **520** can further include an "SGI" field indicating the short guard interval (SGI) used. The "SGI" field can be 1-bit long. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 8 μs. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 4 μs.

The SIGNAL unit **520** can further include a "length" field indicating length of the payload **530**. The "length" field can be 12-bits long. In an embodiment, the "length" field can indicate the length of the payload **530** in units of symbols when A-MPDU is being used. The "length" field can indicate the length of the payload **530** in units of bytes when A-MPDU is not being used. In an embodiment, A-MPDU is used for packed sizes greater than 4095 bytes. The SIGNAL unit **520** can further include an "aggregation" field indicating whether A-MPDU is being used. The "aggregation" field can be 1-bit long.

The SIGNAL unit **520** can further include a "BW" field indicating the bandwidth (BW) used. The "BW" field can be 2-bits long. In various embodiments, the 2-bit "BW" field can indicate whether the bandwidth is 2 MHz, 4 MHz, 8 MHz, or 16 MHz. The SIGNAL unit **520** can further include a "coding" field indicating the type of encoding used. The "coding" field can be 1-bit long.

The SIGNAL unit **520** can further include an "AID" field indicating the air identification (AID) associated with the data unit **500**. The "AID" field can be 12-bits long. The SIGNAL unit **520** can further include a "STBC" field indicating whether space-time block coding (STBC) is used. The "STBC" field can be 1-bit long. The SIGNAL unit **520** can further include a "smoothing" field indicating whether smoothing is recommended on channel estimation. The "smoothing" field can be 1-bit long.

The SIGNAL unit **520** can further include a "CRC" field indicating the result of a cyclic redundancy check (CRC) computed on one or more fields of the SIGNAL unit **520**. The "CRC" field can be 4-bits long. In an embodiment, another error-detection code can be used instead of, or in addition to, the CRC. The SIGNAL unit **520** can further include a "tail" field used to reset the state of a convolution encoder and/or decoder. The "tail" field can be 6-bits long.

The SIGNAL unit **520** can further include one or more reserved bits. As shown in the implementation of Table 1, the SIGNAL unit **520** can include 1 reserved bit. As discussed below, in various embodiments, the reserved bits can be used to carry additional information for different packet types. For example, the reserved bits can include additional information related to acknowledgement (ACK) packets. In some embodiments, one or more of the reserved bits are used as one or more Doppler mitigation bits to signal to the receiver that there are sections in SIGNAL unit **520** which can enable the receiver to mitigate the impact of 'high temporal channel variation' during transmission of the SIGNAL unit **520**.

In an embodiment, the SIGNAL unit **520** can include one or more of the fields shown below in Table 2. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length. In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 2. In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 2. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 2 in the order shown in Table 2. In some embodiments, at least a portion of the information of multiple fields shown in Table 2 is included in a single field. For example, the first and second fields of Table 2 may be collapsed into a single field including the information of both the first and second fields.

TABLE 2

Field of SIG-A (64-Point FFT)	Bits
MCS	4
Num SS	2
SGI	1
Length	12
Aggregation	1
BW	2
Coding	1
AID	13
STBC	1
Beamformed	1
Reserved	0
CRC	8
Tail	6
Total	52

In the aspect shown in Table 2, the SIGNAL unit **520** can include an "MCS" field indicating the modulation coding scheme (MCS) used. The "MCS" field can be 4-bits long. In an embodiment, the "MCS" field may indicate that, for example, quadrature phase-shift keying (QPSK) is used. The SIGNAL unit **520** can further include a "Num SS" field indicating the number of spatial streams used. The "Num SS" field can be 2-bits long. The SIGNAL unit **520** can further include an "SGI" field indicating the short guard interval (SGI) used. The "SGI" field can be 1-bit long. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 8 μs. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 4 μs.

The SIGNAL unit **520** can further include a "length" field indicating length of the payload **530**. The "length" field can be 12-bits long. In an embodiment, the "length" field can indicate the length of the payload **530** in units of symbols when A-MPDU is being used. The "length" field can indicate the length of the payload **530** in units of bytes when A-MPDU is not being used. In an embodiment, A-MPDU is used for packed sizes greater than 4095 bytes. The SIGNAL unit **520** can further include an "aggregation" field indicating whether A-MPDU is being used. The "aggregation" field can be 1-bit long.

The SIGNAL unit **520** can further include a "BW" field indicating the bandwidth (BW) used. The "BW" field can be 2-bits long. In various embodiments, the 2-bit "BW" field can indicate whether the bandwidth is 2 MHz, 4 MHz, 8 MHz, or 16 MHz. The SIGNAL unit **520** can further include a "coding" field indicating the type of encoding used. The "coding" field can be 1-bit long.

The SIGNAL unit **520** can further include an "AID" field indicating the air identification (AID) associated with the data unit **500**. The "AID" field can be 13-bits long. In some embodiments, the "AID" field carries the AID for SU, whereas for MU, the first bit is reserved, the next 6 bits carry group identifier (GID), and the last 6 bits carry a number of space time streams (N_{sts}) for 2^{nd}, 3^{rd} and 4^{th} users. In some embodiments, certain exceptional values of the "AID" field may be used to identify the specific content of the packet, for example, whether the packet is for multicast or broadcast. The SIGNAL unit **520** can further include a "STBC" field indicating whether space-time block coding (STBC) is used. The "STBC" field can be 1-bit long. The SIGNAL unit **520** can further include a "beamformed" field indicating whether a beamforming steering matrix is applied to the waveform in an SU transmission. The "beamformed" field can be 1-bit long.

The SIGNAL unit **520** can further include a "CRC" field indicating the result of a cyclic redundancy check (CRC) computed on one or more fields of the SIGNAL unit **520**. The "CRC" field can be 8-bits or 4-bits long. In an embodiment, another error-detection code can be used instead of, or in addition to, the CRC. The SIGNAL unit **520** can further include a "tail" field used to reset the state of a convolution encoder and/or decoder. The "tail" field can be 6-bits long.

The SIGNAL unit **520** can further include one or more reserved bits. The SIGNAL unit **520** can include, for example, 0 or 4 reserved bits. As discussed below, in various embodiments, the reserved bits can be used to carry additional information for different packet types. For example, the reserved bits can include additional information related to acknowledgement (ACK) packets. In some embodiments, one or more of the reserved bits are used as one or more Doppler mitigation bits to signal to the receiver that there are sections in SIGNAL unit **520** which can enable the receiver to mitigate the impact of 'high temporal channel variation' during transmission of the SIGNAL unit **520**.

In an embodiment, for 32-point FFT signals, the data unit **500** can include a **360** is preamble. The preamble can include a single 4-symbol STF **512**, a single 2-symbol LTF **514**, and a 3-symbol SIGNAL unit **520**. The SIGNAL unit **520** can include one or more of the fields shown below in Table 3. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length. In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 3. In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 3. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 3 in the order shown in Table 3. In some embodiments, at least a portion of the information of multiple fields shown in Table 3 is included in a single field. For example, the first and second fields of Table 3 may be collapsed into a single field including the information of both the first and second fields.

TABLE 3

Field of SIG-A (32-Point FFT)	Bits
MCS	4
Num SS	2
SGI	1
Length	11
Aggregation	1
Coding	1
STBC	1
Reserved	5
CRC	4
Tail	6
Total	36

In the aspect shown in Table 3, the SIGNAL unit **520** can include an "MCS" field indicating the modulation coding scheme (MCS) used. The "MCS" field can be 4-bits long. In an embodiment, the "MCS" field may indicate that, for example, quadrature phase-shift keying (QPSK) is used. The SIGNAL unit **520** can further include a "Num SS" field indicating the number of spatial streams used. The "Num SS" field can be 2-bits long. The SIGNAL unit **520** can further include an "SGI" field indicating the short guard interval (SGI) used. The "SGI" field can be 1-bit long. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 8 μs. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 4 μs.

The SIGNAL unit **520** can further include a "length" field indicating length of the payload **530**. The "length" field can be 11-bit long. In an embodiment, the "length" field can indicate the length of the payload **530** in units of symbols when A-MPDU is being used. The "length" field can indicate the length of the payload **530** in units of bytes when A-MPDU is not being used. In an embodiment, A-MPDU is used for packed sizes greater than 4095 bytes. The SIGNAL unit **520** can further include an "aggregation" field indicating whether A-MPDU is being used. The "aggregation" field can be 1-bit long.

The SIGNAL unit **520** can further include a "coding" field indicating the type of encoding used. The "coding" field can be 1-bit long. The SIGNAL unit **520** can further include a "STBC" field indicating whether space-time block coding (STBC) is used. The "STBC" field can be 1-bit long.

The SIGNAL unit **520** can further include a "CRC" field indicating the result of a cyclic redundancy check (CRC) computed on one or more fields of the SIGNAL unit **520**. The "CRC" field can be 4-bits long. In an embodiment, another error-detection code can be used instead of, or in addition to, the CRC. The SIGNAL unit **520** can further include a "tail" field used to reset the state of a convolution encoder and/or decoder. The "tail" field can be 6-bits long.

The SIGNAL unit **520** can further include one or more reserved bits. As shown in the implementation of Table 3, the SIGNAL unit **520** can include 5 reserved bits. As discussed below, in various embodiments, the reserved bits can be used to carry additional information for different packet types. For example, the reserved bits can include additional information related to acknowledgement (ACK) packets. In some embodiments, one or more of the reserved bits are used as one or more Doppler mitigation bits to signal to the receiver that there are sections in SIGNAL unit **520** which can enable the receiver to mitigate the impact of 'high temporal channel variation' during transmission of the SIGNAL unit **520**.

In the implementation shown in Table 3, the SIGNAL unit **520** for a 32-point FFT can omit one or more fields used in the SIGNAL unit **520** for the 64-point FFT shown above in Table 1. For example, the "BW," "AID," and "smoothing" fields are omitted. In an embodiment, certain fields can be omitted because the receiving device may implicitly know the parameters indicated in those fields.

In various embodiments, symbols, fields, and/or data units can be repeated in order to increase the effective signal-to-noise ratio (SNR) of a transmission. For example, 32-point FFT transmissions can be repeated two times, three times, four times, eight times, etc. In an embodiment, repetition can be accomplished in conjunction with downclocking of the transmission.

In one embodiment, for 32-point FFT signals with a two-time repetition mode, the data unit **500** can include a 440 μs preamble. The preamble can include a single 4-symbol STF **512**, a single 3-symbol LTF **514**, and a 4-symbol SIGNAL unit **520**. The SIGNAL unit **520** can include one or more of the fields shown below in Table 4. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length. In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 4. In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 4. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 4 in the order shown in Table 4. In some embodiments, at least a portion of the information of multiple fields shown in Table 4 is included in a single field. For example, the first and second fields of Table 4 may be collapsed into a single field including the information of both the first and second fields.

TABLE 4

Field of SIG-A (32-Point FFT, 2x Repetition)	Bits
Length	9
Reserved	8
Parity	1
Tail	6
Total	24

In the aspect shown in Table 4, the SIGNAL unit **520** can include a "length" field indicating length of the payload **530**. The "length" field can be 9-bits long. In an embodiment, the "length" field can indicate the length of the payload **530** in units of symbols when A-MPDU is being used. The "length" field can indicate the length of the payload **530** in units of bytes when A-MPDU is not being used. In an embodiment, A-MPDU is used for packed sizes greater than 4095 bytes.

The SIGNAL unit **520** can further include a "parity" field indicating the result of a parity calculated on one or more fields of the SIGNAL unit **520**. The "parity" field can be 1-bit long. In an embodiment, another error-detection code can be used instead of, or in addition to, the parity bit. The SIGNAL unit **520** can further include a "tail" field used to reset the state of a convolution encoder and/or decoder. The "tail" field can be 6-bits long.

The SIGNAL unit **520** can further include one or more reserved bits. As shown in the implementation of Table 4, the SIGNAL unit **520** can include 8 reserved bits. As discussed below, in various embodiments, the reserved bits can be used to carry additional information for different packet types. For example, the reserved bits can include additional information

related to acknowledgement (ACK) packets. In some embodiments, one or more of the reserved bits are used as one or more Doppler mitigation bits to signal to the receiver that there are sections in SIGNAL unit **520** which can enable the receiver to mitigate the impact of 'high temporal channel variation' during transmission of the SIGNAL unit **520**.

In the implementation shown in Table 4, the SIGNAL unit **520** for a 32-point FFT can omit one or more fields used in the SIGNAL unit **520** for the 64-point FFT shown above in Table 1. For example, the "MCS," "Num SS," "SGI," "BW," "AID," "aggregation," "coding," and "STBC" fields are omitted. In an embodiment, certain fields can be omitted because the receiving device may implicitly know the parameters indicated in those fields.

In an embodiment, a single SIGNAL unit **520** format can be used for 32-point FFT in both non-repetition and two-time repetition modes. The single SIGNAL unit **520** can be included in a "combined" preamble. In an embodiment, the combined preamble can be 520 μs long. The preamble can include a single 4-symbol STF **512**, a single 3-symbol LTF **514**, and a 6-symbol SIGNAL unit **520**. The SIGNAL unit **520** can include one or more of the fields shown below in Table 5. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length. In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 5. In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 5. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 5 in the order shown in Table 5. In some embodiments, at least a portion of the information of multiple fields shown in Table 5 is included in a single field. For example, the first and second fields of Table 5 may be collapsed into a single field including the information of both the first and second fields.

TABLE 5

Field of SIG-A (32-Point FFT Combined)	Bits
MCS	4
Num SS	2
SGI	1
Length	11
Aggregation	1
Coding	1
STBC	1
Smoothing	1
Reserved	4
CRC	4
Tail	6
Total	36

In the aspect shown in Table 5, the SIGNAL unit **520** can include an "MCS" field indicating the modulation coding scheme (MCS) used. The "MCS" field can be 4-bits long. In an embodiment, the "MCS" field may indicate that, for example, quadrature phase-shift keying (QPSK) is used. The SIGNAL unit **520** can further include a "Num SS" field indicating the number of spatial streams used. The "Num SS" field can be 2-bits long. The SIGNAL unit **520** can further include an "SGI" field indicating the short guard interval (SGI) used. The "SGI" field can be 1-bit long. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 8 μs. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 4 μs.

The SIGNAL unit **520** can further include a "length" field indicating length of the payload **530**. The "length" field can be 11-bit long. In an embodiment, the "length" field can indicate the length of the payload **530** in units of symbols when A-MPDU is being used. The "length" field can indicate the length of the payload **530** in units of bytes when A-MPDU is not being used. In an embodiment, A-MPDU is used for packed sizes greater than 4095 bytes. The SIGNAL unit **520** can further include an "aggregation" field indicating whether A-MPDU is being used. The "aggregation" field can be 1-bit long.

The SIGNAL unit **520** can further include a "coding" field indicating the type of encoding used. The "coding" field can be 1-bit long. The SIGNAL unit **520** can further include a "STBC" field indicating whether space-time block coding (STBC) is used. The "STBC" field can be 1-bit long. The SIGNAL unit **520** can further include a "smoothing" field indicating whether smoothing is recommended on channel estimation. The "smoothing" field can be 1-bit long.

The SIGNAL unit **520** can further include a "CRC" field indicating the result of a cyclic redundancy check (CRC) computed on one or more fields of the SIGNAL unit **520**. The "CRC" field can be 4-bits long. In an embodiment, another error-detection code can be used instead of, or in addition to, the CRC. The SIGNAL unit **520** can further include a "tail" field used to reset the state of a convolution encoder and/or decoder. The "tail" field can be 6-bits long.

The SIGNAL unit **520** can further include one or more reserved bits. As shown in the implementation of Table 5, the SIGNAL unit **520** can include 4 reserved bits. As discussed below, in various embodiments, the reserved bits can be used to carry additional information for different packet types. For example, the reserved bits can include additional information related to acknowledgement (ACK) packets. In some embodiments, one or more of the reserved bits are used as one or more Doppler mitigation bits to signal to the receiver that there are sections in SIGNAL unit **520** which can enable the receiver to mitigate the impact of 'high temporal channel variation' during transmission of the SIGNAL unit **520**.

In the implementation shown in Table 5, the SIGNAL unit **520** for a 32-point FFT can omit one or more fields used in the SIGNAL unit **520** for the 64-point FFT shown above in Table 1. For example, the "BW" and the "AID" fields are omitted. In an embodiment, certain fields can be omitted because the receiving device may implicitly know the parameters indicated in those fields.

In an embodiment, a single SIGNAL unit **520** format can be used for 32-point FFT in normal and 2× rep modes. The SIGNAL unit **520** can include one or more of the fields shown below in Table 6. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length. In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 6. In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 6. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 6 in the order shown in Table 6. In some embodiments, at least a portion of the information of multiple fields shown in Table 6 is included in a single field. For example, the first and second fields of Table 6 may be collapsed into a single field including the information of both the first and second fields.

TABLE 6

Field of SIG-A (32-Point FFT normal and 2x repetition modes)	Bits
MCS	4
Num SS	2
SGI	1
Length	11
Aggregation	1
Coding	1
STBC	1
Beamformed	1
Reserved	0
CRC	8
Tail	6
Total	36

In the aspect shown in Table 6, the SIGNAL unit **520** can include an "MCS" field indicating the modulation coding scheme (MCS) used. The "MCS" field can be 4-bits long. In an embodiment, the "MCS" field may indicate that, for example, quadrature phase-shift keying (QPSK) is used. The SIGNAL unit **520** can further include a "Num SS" field indicating the number of spatial streams used. The "Num SS" field can be 2-bits long. The SIGNAL unit **520** can further include an "SGI" field indicating the short guard interval (SGI) used. The "SGI" field can be 1-bit long. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 8 μs. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 4 μs.

The SIGNAL unit **520** can further include a "length" field indicating length of the payload **530**. The "length" field can be 11-bit long. In an embodiment, the "length" field can indicate the length of the payload **530** in units of symbols when A-MPDU is being used. The "length" field can indicate the length of the payload **530** in units of bytes when A-MPDU is not being used. In an embodiment, A-MPDU is used for packed sizes greater than 2047 bytes. The SIGNAL unit **520** can further include an "aggregation" field indicating whether A-MPDU is being used. The "aggregation" field can be 1-bit long.

The SIGNAL unit **520** can further include a "coding" field indicating the type of encoding used. The "coding" field can be 1-bit long. The SIGNAL unit **520** can further include a "STBC" field indicating whether space-time block coding (STBC) is used. The "STBC" field can be 1-bit long. The SIGNAL unit **520** can further include a "beamformed" field indicating whether a beamforming steering matrix is applied to the waveform in an SU transmission. The "beamformed" field can be 1-bit long.

The SIGNAL unit **520** can further include a "CRC" field indicating the result of a cyclic redundancy check (CRC) computed on one or more fields of the SIGNAL unit **520**. The "CRC" field can be 4-bits or 8-bits long. In an embodiment, another error-detection code can be used instead of, or in addition to, the CRC. The SIGNAL unit **520** can further include a "tail" field used to reset the state of a convolution encoder and/or decoder. The "tail" field can be 6-bits long.

The SIGNAL unit **520** can further include one or more reserved bits. The SIGNAL unit **520** can include, for example, 0 or 4 reserved bits. As discussed below, in various embodiments, the reserved bits can be used to carry additional information for different packet types. For example, the reserved bits can include additional information related to acknowledgement (ACK) packets. In some embodiments, one or more of the reserved bits are used as one or more Doppler mitigation bits to signal to the receiver that there are sections in SIGNAL unit **520** which can enable the receiver to mitigate the impact of 'high temporal channel variation' during transmission of the SIGNAL unit **520**.

In the implementation shown in Table 6, the SIGNAL unit **520** for a 32-point FFT can omit one or more fields used in the SIGNAL unit **520** for the 64-point FFT shown above in Table 1. For example, the "BW" and the "AID" fields are omitted. In an embodiment, certain fields can be omitted because the receiving device may implicitly know the parameters indicated in those fields.

In an embodiment, a single SIGNAL unit **520** format can be used for a 64-point FFT SIG-B MU mode. The SIGNAL unit **520** can be sent for each user with precoding applied. The SIGNAL unit **520** can include one or more of the fields shown below in Table 7. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length. In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 7. In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 7. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 7 in the order shown in Table 7. In some embodiments, at least a portion of the information of multiple fields shown in Table 7 is included in a single field. For example, the first and second fields of Table 7 may be collapsed into a single field including the information of both the first and second fields.

TABLE 7

Field of SIG-B (64-Point FFT MU mode)	Bits
MCS	4
Coding	1
Reserved	11
CRC	4
Tail	6
Total	26

In the aspect shown in Table 7, the SIGNAL unit **520** can include an "MCS" field indicating the modulation coding scheme (MCS) used. The "MCS" field can be 4-bits long. In an embodiment, the "MCS" field may indicate that, for example, quadrature phase-shift keying (QPSK) is used. The SIGNAL unit **520** can further include a "coding" field indicating the type of encoding used. The "coding" field can be 1-bit long.

The SIGNAL unit **520** can further include a "CRC" field indicating the result of a cyclic redundancy check (CRC) computed on one or more fields of the SIGNAL unit **520**. The "CRC" field can be 4-bits long. In an embodiment, another error-detection code can be used instead of, or in addition to, the CRC. The SIGNAL unit **520** can further include a "tail" field used to reset the state of a convolution encoder and/or decoder. The "tail" field can be 6-bits long.

The SIGNAL unit **520** can further include one or more reserved bits. The SIGNAL unit **520** can include, for example, 11 reserved bits. As discussed below, in various embodiments, the reserved bits can be used to carry additional information for different packet types. For example, the reserved bits can include additional information related to acknowledgement (ACK) packets. In some embodiments, one or more of the reserved bits are used as one or more Doppler mitigation bits to signal to the receiver that there are

sections in SIGNAL unit **520** which can enable the receiver to mitigate the impact of 'high temporal channel variation' during transmission of the SIGNAL unit **520**.

In the implementation shown in Table 7, the SIGNAL unit **520** for a 32-point FFT can omit one or more fields used in the SIGNAL unit **520** for the 64-point FFT shown above in Table 1. For example, the "BW" and the "AID" fields are omitted. In an embodiment, certain fields can be omitted because the receiving device may implicitly know the parameters indicated in those fields.

In an embodiment, for 2 MHz, 64-point FFT signals, the data unit **500** can support multiple users. The preamble can include a 2-symbol SIGNAL unit **520**. The SIGNAL unit **520** can include one or more of the fields shown below in Table 8. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length. In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 8. In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 8. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 8 in the order shown in Table 8. In some embodiments, at least a portion of the information of multiple fields shown in Table 8 is included in a single field. For example, the first and second fields of Table 8 may be collapsed into a single field including the information of both the first and second fields.

TABLE 8

Field of SIG-A (64-Point FFT)	Bits
BW	2
1^{st} Reserved	1
STBC	1
Num SS	2
AID/GID + Nsts	12
2^{nd} Reserved	1
SGI	1
Coding	1
MCS	4
Beamformed	1
Aggregation	1
Length	12
3^{rd} Reserved	3
CRC	4
Tail	6
Total	52

In some embodiments, a first symbol of the SIGNAL unit **520** includes the "BW," "1^{st} Reserved," "STBC," "Num SS," "AID/GID+Nsts," "2^{nd} Reserved," "SGI," "Coding," "MCS," and "Beamformed," fields, and a second symbol of the SIGNAL unit **520** includes the "Aggregation," "Length," "3^{rd} Reserved," "CRC," and "Tail" fields.

In the aspect shown in Table 8, the SIGNAL unit **520** can include a "BW" field indicating the bandwidth (BW) used. The "BW" field can be 2-bits long. In various embodiments, the 2-bit "BW" field can indicate whether the bandwidth is 2 MHz, 4 MHz, 8 MHz, or 16 MHz. The SIGNAL unit **520** can further include a "1^{st} Reserved" bit. The SIGNAL unit **520** can further include a "STBC" field indicating whether space-time block coding (STBC) is used. The "STBC" field can be 1-bit long.

The SIGNAL unit **520** can further include a "Num SS" field indicating the number of spatial streams used. The "Num SS" field can be 2-bits long. The SIGNAL unit **520** can further include an "AID/GID+Nsts" field indicating the air identification (AID) associated with the data unit **500**. The "AID/GID+Nsts" field can be 12-bits long. In some embodiments, the "AID/GID+Nsts" field carries the AID for SU, whereas for MU, the first 6 bits carry GID, and the last 6 bits carry N_{sts} for 2^{nd}, 3^{rd} and 4^{th} users. In some embodiments, certain exceptional values of the "AID/GID+Nsts" field may be used to identify the specific content of the packet, for example, whether the packet is for multicast or broadcast. During SU mode, the "AID" bits of the "AID/GID+Nsts" field can be used for embodiments which use cellular offload, so that other devices can save power during the transmissions. The SIGNAL unit **520** can further include a "2^{nd} Reserved" bit.

The SIGNAL unit **520** can further include an "SGI" field indicating the short guard interval (SGI) used. The "SGI" field can be 1-bit long. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 8 μs. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 4 μs.

The SIGNAL unit **520** can further include a "coding" field indicating the type of encoding used. The "coding" field can be 1-bit long. The SIGNAL unit **520** can further include an "MCS" field indicating the modulation coding scheme (MCS) used. The "MCS" field can be 4-bits long. In an embodiment, the "MCS" field may indicate that, for example, quadrature phase-shift keying (QPSK) is used. The SIGNAL unit **520** can further include a "beamformed" field indicating whether a beamforming steering matrix is applied to the waveform in an SU transmission. The "beamformed" field can be 1-bit long.

The SIGNAL unit **520** can further include an "aggregation" field indicating whether A-MPDU is being used. The "aggregation" field can be 1-bit long. The SIGNAL unit **520** can further include a "length" field indicating length of the payload **530**. The "length" field can be 12-bits long. In an embodiment, the "length" field can indicate the length of the payload **530** in units of symbols when A-MPDU is being used.

The "length" field can indicate the length of the payload **530** in units of bytes when A-MPDU is not being used. In an embodiment, A-MPDU is used for packed sizes greater than 4095 bytes. The SIGNAL unit **520** can further include 3 "3^{rd} Reserved" bits. In alternative embodiments, the "length" field is 9-bits long and the SIGNAL unit **520** includes 6 "3^{rd} Reserved" bits.

The SIGNAL unit **520** can further include a "CRC" field indicating the result of a cyclic redundancy check (CRC) computed on one or more fields of the SIGNAL unit **520**. The "CRC" field can be 4-bits long. In an embodiment, another error-detection code can be used instead of, or in addition to, the CRC. The SIGNAL unit **520** can further include a "tail" field used to reset the state of a convolution encoder and/or decoder. The "tail" field can be 6-bits long.

As discussed below, in various embodiments, the reserved bits can be used to carry additional information for different packet types. For example, the reserved bits can include additional information related to acknowledgement (ACK) packets. In some embodiments, the reserved bits can be used to extend the preceding field. For example, in the example shown in Table 8, the "1^{st} Reserved" bit may be used as a 3^{rd} bit for the "BW" field, the "2^{nd} Reserved bit may be used as a 13^{th} bit for the "AID/GID+Nsts" field, and/or one or more of the "3^{rd} Reserved" bits may be used as additional bits for the "Length" field. In some embodiments, one or more of the reserved bits are used as one or more Doppler mitigation bits to signal to the receiver that there are sections in SIGNAL unit

520 which can enable the receiver to mitigate the impact of 'high temporal channel variation' during transmission of the SIGNAL unit **520**.

In an embodiment, a single SIGNAL unit **520** format can be used for a 64-point FFT SIG-B MU mode. The SIGNAL unit **520** can include one or more of the fields shown below in Table 9. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length. In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 9. In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 9. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 9 in the order shown in Table 9. In some embodiments, at least a portion of the information of multiple fields shown in Table 9 is included in a single field. For example, the first and second fields of Table 9 may be collapsed into a single field including the information of both the first and second fields.

TABLE 9

Field of SIG-B (64-Point FFT MU mode)	Bits
MCS	4
Coding	1
Reserved	7
CRC	8
Tail	6
Total	26

In the aspect shown in Table 9, the SIGNAL unit **520** can include an "MCS" field indicating the modulation coding scheme (MCS) used. The "MCS" field can be 4-bits long. In an embodiment, the "MCS" field may indicate that, for example, quadrature phase-shift keying (QPSK) is used. The SIGNAL unit **520** can further include a "coding" field indicating the type of encoding used. The "coding" field can be 1-bit long.

The SIGNAL unit **520** can further include 7 reserved bits. The SIGNAL unit **520** can further include a "CRC" field indicating the result of a cyclic redundancy check (CRC) computed on one or more fields of the SIGNAL unit **520**. The "CRC" field can be 8-bits long. In an embodiment, another error-detection code can be used instead of, or in addition to, the CRC. The SIGNAL unit **520** can further include a "tail" field used to reset the state of a convolution encoder and/or decoder. The "tail" field can be 6-bits long.

As discussed below, in various embodiments, the reserved bits can be used to carry additional information for different packet types. For example, the reserved bits can include additional information related to acknowledgement (ACK) packets. In some embodiments, one or more of the reserved bits are used as one or more Doppler mitigation bits to signal to the receiver that there are sections in SIGNAL unit **520** which can enable the receiver to mitigate the impact of 'high temporal channel variation' during transmission of the SIGNAL unit **520**.

In an embodiment, for a 1 MHz SIG-A packet, the SIGNAL unit **520** can include one or more of the fields shown below in Table 10. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length. In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 10. In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 10. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 10 in the order shown in Table 10. In some embodiments, at least a portion of the information of multiple fields shown in Table 10 is included in a single field. For example, the first and second fields of Table 10 may be collapsed into a single field including the information of both the first and second fields.

TABLE 10

Field of SIG-A (1 MHz 6 symbols)	Bits
STBC	1
Num SS	2
SGI	1
Coding	1
Beamformed	1
MCS	4
Aggregation	1
Length	11
Reserved	4
CRC	4
Tail	6
Total	36

In the aspect shown in Table 10, the SIGNAL unit **520** can include a "STBC" field indicating whether space-time block coding (STBC) is used. The "STBC" field can be 1-bit long. The SIGNAL unit **520** can further include a "Num SS" field indicating the number of spatial streams used. The "Num SS" field can be 2-bits long.

The SIGNAL unit **520** can further include an "SGI" field indicating the short guard interval (SGI) used. The "SGI" field can be 1-bit long. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 8 μs. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 4 μs.

The SIGNAL unit **520** can further include a "coding" field indicating the type of encoding used. The "coding" field can be 1-bit long. The SIGNAL unit **520** can further include a "beamformed" field indicating whether a beamforming steering matrix is applied to the waveform in an SU transmission. The "beamformed" field can be 1-bit long.

The SIGNAL unit **520** can further include an "MCS" field indicating the modulation coding scheme (MCS) used. The "MCS" field can be 4-bits long. In an embodiment, the "MCS" field may indicate that, for example, quadrature phase-shift keying (QPSK) is used. The SIGNAL unit **520** can further include an "aggregation" field indicating whether A-MPDU is being used. The "aggregation" field can be 1-bit long.

The SIGNAL unit **520** can further include a "length" field indicating length of the payload **530**. The "length" field can be 11-bits long. In an embodiment, the "length" field can indicate the length of the payload **530** in units of symbols when A-MPDU is being used. The "length" field can indicate the length of the payload **530** in units of bytes when A-MPDU is not being used. In an embodiment, A-MPDU is used for packed sizes greater than 2047 bytes.

The SIGNAL unit **520** can further include 4 reserved bits. The SIGNAL unit **520** can further include a "CRC" field indicating the result of a cyclic redundancy check (CRC) computed on one or more fields of the SIGNAL unit **520**. The "CRC" field can be 4-bits long. In an embodiment, another error-detection code can be used instead of, or in addition to, the CRC. The SIGNAL unit **520** can further include a "tail" field used to reset the state of a convolution encoder and/or decoder. The "tail" field can be 6-bits long.

As discussed below, in various embodiments, the reserved bits can be used to carry additional information for different packet types. For example, the reserved bits can include additional information related to acknowledgement (ACK) packets. In some embodiments, the reserved bits can be used to extend the preceding field. For example, in the example shown in Table 10, the reserved bits may be used as additional bits for the "Length" field. In some embodiments, one or more of the reserved bits are used as one or more Doppler mitigation bits to signal to the receiver that there are sections in SIGNAL unit **520** which can enable the receiver to mitigate the impact of 'high temporal channel variation' during transmission of the SIGNAL unit **520**.

In an embodiment, for a 1 MHz SIG-A packet, the SIGNAL unit **520** can include one or more of the fields shown below in Table 11. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length. In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 11. In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 11. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 11 in the order shown in Table 11. In some embodiments, at least a portion of the information of multiple fields shown in Table 11 is included in a single field. For example, the first and second fields of Table 11 may be collapsed into a single field including the information of both the first and second fields.

TABLE 11

Field of SIG-A (1 MHz 5 symbols)	Bits
STBC	1
Num SS	2
SGI	1
Coding	1
Beamformed	1
MCS	4
Aggregation	1
Length	9
Reserved	0
CRC	4
Tail	6
Total	30

In the aspect shown in Table 11, the SIGNAL unit **520** can include a "STBC" field indicating whether space-time block coding (STBC) is used. The "STBC" field can be 1-bit long. The SIGNAL unit **520** can further include a "Num SS" field indicating the number of spatial streams used. The "Num SS" field can be 2-bits long.

The SIGNAL unit **520** can further include an "SGI" field indicating the short guard interval (SGI) used. The "SGI" field can be 1-bit long. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 8 μs. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 4 μs.

The SIGNAL unit **520** can further include a "coding" field indicating the type of encoding used. The "coding" field can be 1-bit long. The SIGNAL unit **520** can further include a "beamformed" field indicating whether a beamforming steering matrix is applied to the waveform in an SU transmission. The "beamformed" field can be 1-bit long.

The SIGNAL unit **520** can further include an "MCS" field indicating the modulation coding scheme (MCS) used. The "MCS" field can be 4-bits long. In an embodiment, the "MCS" field may indicate that, for example, quadrature phase-shift keying (QPSK) is used. The SIGNAL unit **520** can further include an "aggregation" field indicating whether A-MPDU is being used. The "aggregation" field can be 1-bit long.

The SIGNAL unit **520** can further include a "length" field indicating length of the payload **530**. The "length" field can be 9-bits long. In an embodiment, the "length" field can indicate the length of the payload **530** in units of symbols when A-MPDU is being used. The "length" field can indicate the length of the payload **530** in units of bytes when A-MPDU is not being used. In an embodiment, A-MPDU is used for packed sizes greater than 511 bytes.

The SIGNAL unit **520** can further include 0 reserved bits. The SIGNAL unit **520** can further include a "CRC" field indicating the result of a cyclic redundancy check (CRC) computed on one or more fields of the SIGNAL unit **520**. The "CRC" field can be 4-bits long. In an embodiment, another error-detection code can be used instead of, or in addition to, the CRC. The SIGNAL unit **520** can further include a "tail" field used to reset the state of a convolution encoder and/or decoder. The "tail" field can be 6-bits long.

In an embodiment, for a 1 MHz SIG-A packet, the SIGNAL unit **520** can include one or more of the fields shown below in Table 12. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length. In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 12. In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 12. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 12 in the order shown in Table 12. In some embodiments, at least a portion of the information of multiple fields shown in Table 12 is included in a single field. For example, the first and second fields of Table 12 may be collapsed into a single field including the information of both the first and second fields.

TABLE 12

Field of SIG-A (1 MHz 5 symbols)	Bits
STBC	1
SGI	1
MCS	4
Coding	1
Aggregation	1
Length	9
Reserved	3
CRC	4
Tail	6
Total	30

In the aspect shown in Table 12, the SIGNAL unit **520** can include a "STBC" field indicating whether space-time block coding (STBC) is used. The "STBC" field can be 1-bit long. The SIGNAL unit **520** can further include an "SGI" field indicating the short guard interval (SGI) used. The "SGI" field can be 1-bit long. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 8 μs. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 4 μs.

The SIGNAL unit **520** can further include an "MCS" field indicating the modulation coding scheme (MCS) used. The "MCS" field can be 4-bits long. In an embodiment, the "MCS" field may indicate that, for example, quadrature phase-shift keying (QPSK) is used. The SIGNAL unit **520**

can further include a "coding" field indicating the type of encoding used. The "coding" field can be 1-bit long.

The SIGNAL unit **520** can further include an "aggregation" field indicating whether A-MPDU is being used. The "aggregation" field can be 1-bit long. The SIGNAL unit **520** can further include a "length" field indicating length of the payload **530**. The "length" field can be 9-bits long. In an embodiment, the "length" field can indicate the length of the payload **530** in units of symbols when A-MPDU is being used. The "length" field can indicate the length of the payload **530** in units of bytes when A-MPDU is not being used. In an embodiment, A-MPDU is used for packed sizes greater than 511 bytes.

The SIGNAL unit **520** can further include 3 reserved bits. The SIGNAL unit **520** can further include a "CRC" field indicating the result of a cyclic redundancy check (CRC) computed on one or more fields of the SIGNAL unit **520**. The "CRC" field can be 4-bits long. In an embodiment, another error-detection code can be used instead of, or in addition to, the CRC. The SIGNAL unit **520** can further include a "tail" field used to reset the state of a convolution encoder and/or decoder. The "tail" field can be 6-bits long.

As discussed below, in various embodiments, the reserved bits can be used to carry additional information for different packet types. For example, the reserved bits can include additional information related to acknowledgement (ACK) packets. In some embodiments, the reserved bits can be used to extend the preceding field. For example, in the example shown in Table 12, one or more of the reserved bits may be used as additional bits for the "Length" field. In some embodiments, one or more of the reserved bits are used as one or more Doppler mitigation bits to signal to the receiver that there are sections in SIGNAL unit **520** which can enable the receiver to mitigate the impact of 'high temporal channel variation' during transmission of the SIGNAL unit **520**.

In an embodiment, for a 1 MHz SIG-A packet, the SIGNAL unit **520** can include one or more of the fields shown below in Table 13. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length. In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 13. In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 13. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 13 in the order shown in Table 13. In some embodiments, at least a portion of the information of multiple fields shown in Table 13 is included in a single field. For example, the first and second fields of Table 13 may be collapsed into a single field including the information of both the first and second fields.

TABLE 13

Field of SIG-A (1 MHz 6 symbols)	Bits
STBC	1
SGI	1
MCS	4
Aggregation	1
Length	9
Reserved	1
Parity	1
Tail	6
Total	24

In the aspect shown in Table 13, the SIGNAL unit **520** can include a "STBC" field indicating whether space-time block coding (STBC) is used. The "STBC" field can be 1-bit long. The SIGNAL unit **520** can further include an "SGI" field indicating the short guard interval (SGI) used. The "SGI" field can be 1-bit long. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 8 μs. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 4 μs.

The SIGNAL unit **520** can further include an "MCS" field indicating the modulation coding scheme (MCS) used. The "MCS" field can be 4-bits long. In an embodiment, the "MCS" field may indicate that, for example, quadrature phase-shift keying (QPSK) is used. The SIGNAL unit **520** can further include an "aggregation" field indicating whether A-MPDU is being used. The "aggregation" field can be 1-bit long.

The SIGNAL unit **520** can further include a "length" field indicating length of the payload **530**. The "length" field can be 9-bits long. In an embodiment, the "length" field can indicate the length of the payload **530** in units of symbols when A-MPDU is being used. The "length" field can indicate the length of the payload **530** in units of bytes when A-MPDU is not being used. In an embodiment, A-MPDU is used for packed sizes greater than 511 bytes.

The SIGNAL unit **520** can further include 1 reserved bit. The SIGNAL unit **520** can further include a "parity" field indicating the result of a parity calculated on one or more fields of the SIGNAL unit **520**. The "parity" field can be 1-bit long. In an embodiment, another error-detection code can be used instead of, or in addition to, the parity bit. The SIGNAL unit **520** can further include a "tail" field used to reset the state of a convolution encoder and/or decoder. The "tail" field can be 6-bits long.

As discussed below, in various embodiments, the reserved bit can be used to carry additional information for different packet types. For example, the reserved bit can include additional information related to acknowledgement (ACK) packets. In some embodiments, the reserved bit can be used to extend the preceding field. For example, in the example shown in Table 13, the reserved bit may be used as an additional bit for the "Length" field. In some embodiments, one or more of the reserved bits are used as one or more Doppler mitigation bits to signal to the receiver that there are sections in SIGNAL unit **520** which can enable the receiver to mitigate the impact of 'high temporal channel variation' during transmission of the SIGNAL unit **520**.

In an embodiment, a single SIGNAL unit **520** format can be used for a 64-point FFT SIG-B MU mode. The SIGNAL unit **520** can include one or more of the fields shown below in Table 14. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length. In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 14. In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 14. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 14 in the order shown in Table 14. In some embodiments, at least a portion of the information of multiple fields shown in Table 14 is included in a single field. For example, the first and second fields of Table 14 may be collapsed into a single field including the information of both the first and second fields.

TABLE 14

Field of SIG-B (64-Point FFT MU mode)	Bits
MCS	4
Coding	1
Length	9-11
Reserved	0-2
CRC	4
Tail	6
Total	26

In the aspect shown in Table 14, the SIGNAL unit **520** can include an "MCS" field indicating the modulation coding scheme (MCS) used. The "MCS" field can be 4-bits long. In an embodiment, the "MCS" field may indicate that, for example, quadrature phase-shift keying (QPSK) is used. The SIGNAL unit **520** can further include a "coding" field indicating the type of encoding used. The "coding" field can be 1-bit long.

The SIGNAL unit **520** can further include a "length" field indicating length of the payload **530**. The "length" field can be 9-11 bits long. In an embodiment, the "length" field can indicate the length of the payload **530** in units of symbols when A-MPDU is being used. The "length" field can indicate the length of the payload **530** in units of bytes when A-MPDU is not being used. The SIGNAL unit **520** can further include 0-2 reserved bits. In an embodiment the total of the bits used for the Length field and the reserved bits is 11. In such embodiments, the reserved bits can be used to extend the preceding field. For example, in the example shown in Table 14, the reserved bits may be used as additional bits for the "Length" field.

The SIGNAL unit **520** can further include a "CRC" field indicating the result of a cyclic redundancy check (CRC) computed on one or more fields of the SIGNAL unit **520**. The "CRC" field can be 4-bits long. In an embodiment, another error-detection code can be used instead of, or in addition to, the CRC. The SIGNAL unit **520** can further include a "tail" field used to reset the state of a convolution encoder and/or decoder. The "tail" field can be 6-bits long.

As discussed below, in various embodiments, the reserved bits can be used to carry additional information for different packet types. For example, the reserved bits can include additional information related to acknowledgement (ACK) packets. In some embodiments, one or more of the reserved bits are used as one or more Doppler mitigation bits to signal to the receiver that there are sections in SIGNAL unit **520** which can enable the receiver to mitigate the impact of 'high temporal channel variation' during transmission of the SIGNAL unit **520**.

In an embodiment, for 2 MHz, 64-point FFT signals, the data unit **500** can support multiple users. The preamble can include a 2-symbol SIGNAL unit **520**. The SIGNAL unit **520** can include one or more of the fields shown below in Table 15. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length. In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 15. In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 15. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 15 in the order shown in Table 15. In some embodiments, at least a portion of the information of multiple fields shown in Table 15 is included in a single field. For example, the first and second fields of Table 15 may be collapsed into a single field including the information of both the first and second fields.

TABLE 15

Field of SIG-A (64-Point FFT)	Bits
BW	2
1st Reserved	1
STBC	1
Num SS	2
AID/GID + Nsts	12
2nd Reserved	1
SGI	1
Coding	2
MCS	4
Beamformed	1
Aggregation	1
Length	9
3rd Reserved	5
CRC	4
Tail	6
Total	52

In some embodiments, a first symbol of the SIGNAL unit **520** includes the "BW," "1^{st} Reserved," "STBC," "Num SS," "AID/GID+Nsts," "2^{nd} Reserved," "SGI," "Coding," and "MCS," fields, and a second symbol of the SIGNAL unit **520** includes the "Beamformed," "Aggregation," "Length," "3^{rd} Reserved," "CRC," and "Tail" fields.

In the aspect shown in Table 15, the SIGNAL unit **520** can include a "BW" field indicating the bandwidth (BW) used. The "BW" field can be 2-bits long. In various embodiments, the 2-bit "BW" field can indicate whether the bandwidth is 2 MHz, 4 MHz, 8 MHz, or 16 MHz. The SIGNAL unit **520** can further include a "1^{st} Reserved" bit. The SIGNAL unit **520** can further include a "STBC" field indicating whether space-time block coding (STBC) is used. The "STBC" field can be 1-bit long.

The SIGNAL unit **520** can further include a "Num SS" field indicating the number of spatial streams used. The "Num SS" field can be 2-bits long. The SIGNAL unit **520** can further include an "AID/GID+Nsts" field indicating the air identification (AID) associated with the data unit **500**. The "AID/GID+Nsts" field can be 12-bits long and may include a PAID field as discussed above. In some embodiments, the "AID/GID+Nsts" field carries the AID for SU, whereas for MU, the first 6 bits carry GID, and the last 6 bits carry N_{sts} for 2^{nd}, 3^{rd} and 4^{th} users. In some embodiments, certain exceptional values of the "AID/GID+Nsts" field may be used to identify the specific content of the packet, for example, whether the packet is for multicast or broadcast. During SU mode, the "AID" bits of the "AID/GID+Nsts" field can be used for embodiments which use cellular offload, so that other devices can save power during the transmissions. The SIGNAL unit **520** can further include a "2^{nd} Reserved" bit.

The SIGNAL unit **520** can further include an "SGI" field indicating the short guard interval (SGI) used. The "SGI" field can be 1-bit long. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 8 μs. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 4 μs.

The SIGNAL unit **520** can further include a "coding" field indicating the type of encoding used. The "coding" field can be 2-bit long. The first bit of the "coding" field can indicate coding type for a single user, or for user 0 if multi-user. The second bit of the "coding" field can be used to indicate

whether LDPC encoding resulted in an extra symbol. If multi-user, the second bit of the "coding" field can be used to indicate whether low-density parity-check (LDPC) encoding resulted in an extra symbol for any of the users. The SIGNAL unit **520** can further include an "MCS" field indicating the modulation coding scheme (MCS) used. The "MCS" field can be 4-bits long. If multi-user, some bits of the "MCS" field may be used to indicate coding for users 1-3. For example, the first, second, and third bits of the "MCS" field may be used to indicate coding for users 1, 2, and 3, respectively. In an embodiment, the "MCS" field may indicate that, for example, quadrature phase-shift keying (QPSK) is used.

The SIGNAL unit **520** can further include a "beamformed" field indicating whether a beamforming steering matrix is applied to the waveform in an SU transmission. The "beamformed" field can be 1-bit long. The SIGNAL unit **520** can further include an "aggregation" field indicating whether A-MPDU is being used. The "aggregation" field can be 1-bit long. The SIGNAL unit **520** can further include a "length" field indicating length of the payload **530**. The "length" field can be 9-bits long. In an embodiment, the "length" field can indicate the length of the payload **530** in units of symbols when A-MPDU is being used. The "length" field can indicate the length of the payload **530** in units of bytes when A-MPDU is not being used. In an embodiment, A-MPDU is used for packed sizes greater than 511 bytes. The SIGNAL unit **520** can further include 5 "3^{rd} Reserved" bits.

The SIGNAL unit **520** can further include a "CRC" field indicating the result of a cyclic redundancy check (CRC) computed on one or more fields of the SIGNAL unit **520**. The "CRC" field can be 4-bits long. In an embodiment, another error-detection code can be used instead of, or in addition to, the CRC. The SIGNAL unit **520** can further include a "tail" field used to reset the state of a convolution encoder and/or decoder. The "tail" field can be 6-bits long.

As discussed below, in various embodiments, the reserved bits can be used to carry additional information for different packet types. For example, the reserved bits can include additional information related to acknowledgement (ACK) packets. In some embodiments, the reserved bits can be used to extend the preceding field. For example, in the example shown in Table 14, the "1^{st} Reserved" bit may be used as a 3^{rd} bit for the "BW" field, the "2^{nd} Reserved bit may be used as a 13^{th} bit for the "AID/GID+Nsts" field, and/or one or more of the "3^{rd} Reserved" bits may be used as additional bits for the "Length" field. In some embodiments, one or more of the reserved bits are used as one or more Doppler mitigation bits to signal to the receiver that there are sections in SIGNAL unit **520** which can enable the receiver to mitigate the impact of 'high temporal channel variation' during transmission of the SIGNAL unit **520**.

In an embodiment, a single SIGNAL unit **520** format can be used for a 64-point FFT SIG-B MU mode. The SIGNAL unit **520** can be sent for each user with precoding applied. The SIGNAL unit **520** can include one or more of the fields shown below in Table 16. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length. In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 16. In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 16. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 16 in the order shown in Table 16. In some embodiments, at least a portion of the information of multiple fields shown in Table 16 is included in a single field. For example, the first and second fields of Table 16 may be collapsed into a single field including the information of both the first and second fields.

TABLE 16

Field of SIG-B (64-Point FFT MU mode)	Bits
MCS	4
Reserved	8
CRC	8
Tail	6
Total	26

In the aspect shown in Table 16, the SIGNAL unit **520** can include an "MCS" field indicating the modulation coding scheme (MCS) used. The "MCS" field can be 4-bits long. If multi-user, some bits of the "MCS" field may be used to indicate coding for users 1-3. For example, the first, second, and third bits of the "MCS" field may be used to indicate coding for users 1, 2, and 3, respectively. In an embodiment, the "MCS" field may indicate that, for example, quadrature phase-shift keying (QPSK) is used.

The SIGNAL unit **520** can further include a "CRC" field indicating the result of a cyclic redundancy check (CRC) computed on one or more fields of the SIGNAL unit **520**. The "CRC" field can be 8-bits long. In an embodiment, another error-detection code can be used instead of, or in addition to, the CRC. The SIGNAL unit **520** can further include a "tail" field used to reset the state of a convolution encoder and/or decoder. The "tail" field can be 6-bits long.

The SIGNAL unit **520** can further include one or more reserved bits. The SIGNAL unit **520** can include, for example, 8 reserved bits. As discussed below, in various embodiments, the reserved bits can be used to carry additional information for different packet types. For example, the reserved bits can include additional information related to acknowledgement (ACK) packets. In some embodiments, one or more of the reserved bits are used as one or more Doppler mitigation bits to signal to the receiver that there are sections in SIGNAL unit **520** which can enable the receiver to mitigate the impact of 'high temporal channel variation' during transmission of the SIGNAL unit **520**.

In the implementation shown in Table 16, the SIGNAL unit **520** for a 32-point FFT can omit one or more fields used in the SIGNAL unit **520** for the 64-point FFT shown above in Table 1. For example, the "BW" and the "AID" fields are omitted. In an embodiment, certain fields can be omitted because the receiving device may implicitly know the parameters indicated in those fields.

In an embodiment, for a 1 MHz SIG-A packet, the SIGNAL unit **520** can include one or more of the fields shown below in Table 17. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length. In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 17. In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 17. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 17 in the order shown in Table 17. In some embodiments, at least a portion of the information of multiple fields shown in Table 17 is included in a single field. For example, the first and second fields of Table 17 may be collapsed into a single field including the information of both the first and second fields.

TABLE 17

Field of SIG-A (1 MHz 6 symbols)	Bits
STBC	1
Num SS	2
SGI	1
Coding	2
Beamformed	1
MCS	4
Aggregation	1
Length	9
Reserved	5
CRC	4
Tail	6
Total	36

In the aspect shown in Table 17, the SIGNAL unit **520** can include a "STBC" field indicating whether space-time block coding (STBC) is used. The "STBC" field can be 1-bit long. The SIGNAL unit **520** can further include a "Num SS" field indicating the number of spatial streams used. The "Num SS" field can be 2-bits long.

The SIGNAL unit **520** can further include an "SGI" field indicating the short guard interval (SGI) used. The "SGI" field can be 1-bit long. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 8 μs. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 4 μs.

The SIGNAL unit **520** can further include a "coding" field indicating the type of encoding used. The "coding" field can be 2-bit long. The first bit of the "coding" field can indicate coding type for a single user, or for user 0 if multi-user. The second bit of the "coding" field can be used to indicate whether LDPC encoding resulted in an extra symbol. If multi-user, the second bit of the "coding" field can be used to indicate whether LDPC encoding resulted in an extra symbol for any of the users. The SIGNAL unit **520** can further include a "beamformed" field indicating whether a beamforming steering matrix is applied to the waveform in an SU transmission. The "beamformed" field can be 1-bit long.

The SIGNAL unit **520** can further include an "MCS" field indicating the modulation coding scheme (MCS) used. The "MCS" field can be 4-bits long. If multi-user, some bits of the "MCS" field may be used to indicate coding for users 1-3. For example, the first, second, and third bits of the "MCS" field may be used to indicate coding for users 1, 2, and 3, respectively. In an embodiment, the "MCS" field may indicate that, for example, quadrature phase-shift keying (QPSK) is used. The SIGNAL unit **520** can further include an "aggregation" field indicating whether A-MPDU is being used. The "aggregation" field can be 1-bit long.

The SIGNAL unit **520** can further include a "length" field indicating length of the payload **530**. The "length" field can be 9-bits long. In an embodiment, the "length" field can indicate the length of the payload **530** in units of symbols when A-MPDU is being used. The "length" field can indicate the length of the payload **530** in units of bytes when A-MPDU is not being used. In an embodiment, A-MPDU is used for packed sizes greater than 511 bytes.

The SIGNAL unit **520** can further include 5 reserved bits. The SIGNAL unit **520** can further include a "CRC" field indicating the result of a cyclic redundancy check (CRC) computed on one or more fields of the SIGNAL unit **520**. The "CRC" field can be 4-bits long. In an embodiment, another error-detection code can be used instead of, or in addition to, the CRC. The SIGNAL unit **520** can further include a "tail" field used to reset the state of a convolution encoder and/or decoder. The "tail" field can be 6-bits long.

As discussed below, in various embodiments, the reserved bits can be used to carry additional information for different packet types. For example, the reserved bits can include additional information related to acknowledgement (ACK) packets. In some embodiments, the reserved bits can be used to extend the preceding field. For example, in the example shown in Table 17, one or more of the reserved bits may be used as additional bits for the "Length" field. In some embodiments, one or more of the reserved bits are used as one or more Doppler mitigation bits to signal to the receiver that there are sections in SIGNAL unit **520** which can enable the receiver to mitigate the impact of 'high temporal channel variation' during transmission of the SIGNAL unit **520**.

In an embodiment, for a 1 MHz SIG-A packet, the SIGNAL unit **520** can include one or more of the fields shown below in Table 18. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length. In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 18. In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 18. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 18 in the order shown in Table 18. In some embodiments, at least a portion of the information of multiple fields shown in Table 18 is included in a single field. For example, the first and second fields of Table 18 may be collapsed into a single field including the information of both the first and second fields.

TABLE 18

Field of SIG-A (1 MHz 8 symbols)	Bits
STBC	1
Num SS	2
SGI	1
Coding	2
Beamformed	1
MCS	4
Aggregation	1
AID	9-13
1st Reserved	2-6
Length	9
2nd Reserved	2
CRC	4
Tail	6
Total	48

In the aspect shown in Table 18, the SIGNAL unit **520** can include a "STBC" field indicating whether space-time block coding (STBC) is used. The "STBC" field can be 1-bit long. The SIGNAL unit **520** can further include a "Num SS" field indicating the number of spatial streams used. The "Num SS" field can be 2-bits long.

The SIGNAL unit **520** can further include an "SGI" field indicating the short guard interval (SGI) used. The "SGI" field can be 1-bit long. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 8 μs. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 4 μs.

The SIGNAL unit **520** can further include a "coding" field indicating the type of encoding used. The "coding" field can be 2-bit long. The first bit of the "coding" field can indicate coding type for a single user, or for user 0 if multi-user. The second bit of the "coding" field can be used to indicate whether LDPC encoding resulted in an extra symbol. If multi-

user, the second bit of the "coding" field can be used to indicate whether LDPC encoding resulted in an extra symbol for any of the users. The SIGNAL unit **520** can further include a "beamformed" field indicating whether a beamforming steering matrix is applied to the waveform in an SU transmission. The "beamformed" field can be 1-bit long.

The SIGNAL unit **520** can further include an "MCS" field indicating the modulation coding scheme (MCS) used. The "MCS" field can be 4-bits long. If multi-user, some bits of the "MCS" field may be used to indicate coding for users 1-3. For example, the first, second, and third bits of the "MCS" field may be used to indicate coding for users 1, 2, and 3, respectively. In an embodiment, the "MCS" field may indicate that, for example, quadrature phase-shift keying (QPSK) is used. The SIGNAL unit **520** can further include an "aggregation" field indicating whether A-MPDU is being used. The "aggregation" field can be 1-bit long.

The SIGNAL unit **520** can further include an "AID" field indicating the air identification (AID) associated with the data unit **500**. The "AID" field can be from 9 to 13-bits long and may include a PAID field as discussed above. The SIGNAL unit **520** can further include from 2 to 6 1^{st} reserved bits. The total of the bits for the "AID" field and the 1^{st} reserved bits may be 15. The SIGNAL unit **520** can further include a "length" field indicating length of the payload **530**. The "length" field can be 9-bits long. In an embodiment, the "length" field can indicate the length of the payload **530** in units of symbols when A-MPDU is being used. The "length" field can indicate the length of the payload **530** in units of bytes when A-MPDU is not being used. In an embodiment, A-MPDU is used for packed sizes greater than 511 bytes.

The SIGNAL unit **520** can further include 2 2^{nd} reserved bits. The SIGNAL unit **520** can further include a "CRC" field indicating the result of a cyclic redundancy check (CRC) computed on one or more fields of the SIGNAL unit **520**. The "CRC" field can be 4-bits long. In an embodiment, another error-detection code can be used instead of, or in addition to, the CRC. The SIGNAL unit **520** can further include a "tail" field used to reset the state of a convolution encoder and/or decoder. The "tail" field can be 6-bits long.

As discussed below, in various embodiments, the reserved bits can be used to carry additional information for different packet types. For example, the reserved bits can include additional information related to acknowledgement (ACK) packets. In some embodiments, the reserved bits can be used to extend the preceding field. For example, in the example shown in Table 18, one or more of the 1^{st} reserved bits may be used as additional bits for the "AID" field, and one or more of the 2^{nd} reserved bits may be used as additional bits for the "Length" field. In some embodiments, one or more of the reserved bits are used as one or more Doppler mitigation bits to signal to the receiver that there are sections in SIGNAL unit **520** which can enable the receiver to mitigate the impact of 'high temporal channel variation' during transmission of the SIGNAL unit **520**.

In an embodiment, for a 1 MHz SIG-A packet, the SIGNAL unit **520** can include one or more of the fields shown below in Table 19. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length. In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 19. In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 19. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 19 in the order shown in Table 19. In some embodiments, at least a portion of the information of multiple fields shown in Table 19 is included in a single field. For example, the first and second fields of Table 19 may be collapsed into a single field including the information of both the first and second fields.

TABLE 19

Field of SIG-A (1 MHz 7 symbols)	Bits
STBC	1
Num SS	2
SGI	1
Coding	2
Beamformed	1
MCS	4
Aggregation	1
AID	9
Reserved	2
Length	9
CRC	4
Tail	6
Total	42

In the aspect shown in Table 19, the SIGNAL unit **520** can include a "STBC" field indicating whether space-time block coding (STBC) is used. The "STBC" field can be 1-bit long. The SIGNAL unit **520** can further include a "Num SS" field indicating the number of spatial streams used. The "Num SS" field can be 2-bits long.

The SIGNAL unit **520** can further include an "SGI" field indicating the short guard interval (SGI) used. The "SGI" field can be 1-bit long. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 8 μs. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 4 μs.

The SIGNAL unit **520** can further include a "coding" field indicating the type of encoding used. The "coding" field can be 2-bit long. The first bit of the "coding" field can indicate coding type for a single user, or for user 0 if multi-user. The second bit of the "coding" field can be used to indicate whether LDPC encoding resulted in an extra symbol. If multi-user, the second bit of the "coding" field can be used to indicate whether LDPC encoding resulted in an extra symbol for any of the users. The SIGNAL unit **520** can further include a "beamformed" field indicating whether a beamforming steering matrix is applied to the waveform in an SU transmission. The "beamformed" field can be 1-bit long.

The SIGNAL unit **520** can further include an "MCS" field indicating the modulation coding scheme (MCS) used. The "MCS" field can be 4-bits long. If multi-user, some bits of the "MCS" field may be used to indicate coding for users 1-3. For example, the first, second, and third bits of the "MCS" field may be used to indicate coding for users 1, 2, and 3, respectively. In an embodiment, the "MCS" field may indicate that, for example, quadrature phase-shift keying (QPSK) is used. The SIGNAL unit **520** can further include an "aggregation" field indicating whether A-MPDU is being used. The "aggregation" field can be 1-bit long.

The SIGNAL unit **520** can further include an "AID" field indicating the air identification (AID) associated with the data unit **500**. The "AID" field can be 9-bits long and may include a PAID field as discussed above. The SIGNAL unit **520** can further include 2 reserved bits. The SIGNAL unit **520** can further include a "length" field indicating length of the payload **530**. The "length" field can be 9-bits long. In an embodiment, the "length" field can indicate the length of the payload **530** in units of symbols when A-MPDU is being used. The "length" field can indicate the length of the payload **530** in

units of bytes when A-MPDU is not being used. In an embodiment, A-MPDU is used for packed sizes greater than 511 bytes.

The SIGNAL unit **520** can further include a "CRC" field indicating the result of a cyclic redundancy check (CRC) computed on one or more fields of the SIGNAL unit **520**. The "CRC" field can be 4-bits long. In an embodiment, another error-detection code can be used instead of, or in addition to, the CRC. The SIGNAL unit **520** can further include a "tail" field used to reset the state of a convolution encoder and/or decoder. The "tail" field can be 6-bits long.

As discussed below, in various embodiments, the reserved bits can be used to carry additional information for different packet types. For example, the reserved bits can include additional information related to acknowledgement (ACK) packets. In some embodiments, the reserved bits can be used to extend the preceding field. For example, in the example shown in Table 19, one or more of the reserved bits may be used as additional bits for the "AID" field. In some embodiments, one or more of the reserved bits are used as one or more Doppler mitigation bits to signal to the receiver that there are sections in SIGNAL unit **520** which can enable the receiver to mitigate the impact of 'high temporal channel variation' during transmission of the SIGNAL unit **520**.

In an embodiment, for a 1 MHz SIG-A packet, the SIGNAL unit **520** can include one or more of the fields shown below in Table 20. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length. In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 20. In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 20. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 20 in the order shown in Table 20. In some embodiments, at least a portion of the information of multiple fields shown in Table 20 is included in a single field. For example, the first and second fields of Table 20 may be collapsed into a single field including the information of both the first and second fields.

TABLE 20

Field of SIG-A (1 MHz 7 symbols)	Bits
STBC	1
Num SS	2
SGI	1
Coding	2
Beamformed	1
MCS	4
Aggregation	1
AID	12
1^{st} Reserved	0-6
Length	9
2^{nd} Reserved	0-6
CRC	4
Tail	6
Total	43-49

In the aspect shown in Table 20, the SIGNAL unit **520** can include a "STBC" field indicating whether space-time block coding (STBC) is used. The "STBC" field can be 1-bit long. The SIGNAL unit **520** can further include a "Num SS" field indicating the number of spatial streams used. The "Num SS" field can be 2-bits long.

The SIGNAL unit **520** can further include an "SGI" field indicating the short guard interval (SGI) used. The "SGI" field can be 1-bit long. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 8 μs. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 4 μs.

The SIGNAL unit **520** can further include a "coding" field indicating the type of encoding used. The "coding" field can be 2-bit long. The first bit of the "coding" field can indicate coding type for a single user, or for user 0 if multi-user. The second bit of the "coding" field can be used to indicate whether LDPC encoding resulted in an extra symbol. If multi-user, the second bit of the "coding" field can be used to indicate whether LDPC encoding resulted in an extra symbol for any of the users. The SIGNAL unit **520** can further include a "beamformed" field indicating whether a beamforming steering matrix is applied to the waveform in an SU transmission. The "beamformed" field can be 1-bit long.

The SIGNAL unit **520** can further include an "MCS" field indicating the modulation coding scheme (MCS) used. The "MCS" field can be 4-bits long. If multi-user, some bits of the "MCS" field may be used to indicate coding for users 1-3. For example, the first, second, and third bits of the "MCS" field may be used to indicate coding for users 1, 2, and 3, respectively. In an embodiment, the "MCS" field may indicate that, for example, quadrature phase-shift keying (QPSK) is used. The SIGNAL unit **520** can further include an "aggregation" field indicating whether A-MPDU is being used. The "aggregation" field can be 1-bit long.

The SIGNAL unit **520** can further include an "AID" field indicating the air identification (AID) associated with the data unit **500**. The "AID" field can be 12-bits long and may include a PAID field as discussed above. The SIGNAL unit **520** can further include 0-6 1^{st} reserved bits.

The SIGNAL unit **520** can further include a "length" field indicating length of the payload **530**. The "length" field can be 9-bits long. In an embodiment, the "length" field can indicate the length of the payload **530** in units of symbols when A-MPDU is being used. The "length" field can indicate the length of the payload **530** in units of bytes when A-MPDU is not being used. In an embodiment, A-MPDU is used for packed sizes greater than 511 bytes. The SIGNAL unit **520** can further include 0-6 2^{nd} reserved bits.

The SIGNAL unit **520** can further include a "CRC" field indicating the result of a cyclic redundancy check (CRC) computed on one or more fields of the SIGNAL unit **520**. The "CRC" field can be 4-bits long. In an embodiment, another error-detection code can be used instead of, or in addition to, the CRC. The SIGNAL unit **520** can further include a "tail" field used to reset the state of a convolution encoder and/or decoder. The "tail" field can be 6-bits long.

In an embodiment, for a 1 MHz SIG-A packet, the SIGNAL unit **520** can include one or more of the fields shown below in Table 21. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length. In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 21. In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 21. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 21 in the order shown in Table 21. In some embodiments, at least a portion of the information of multiple fields shown in Table 21 is included in a single field. For example, the first and second fields of Table 21 may be collapsed into a single field including the information of both the first and second fields.

TABLE 21

Field of SIG-A (1 MHz 7 symbols)	Bits
STBC	1
Num SS	2
SGI	1
Coding	1
MCS	4
Aggregation	1
Length	9
Doppler/Reserved	1
CRC	4
Tail	0
Total	24

In the aspect shown in Table 21, the SIGNAL unit **520** can include a "STBC" field indicating whether space-time block coding (STBC) is used. The "STBC" field can be 1-bit long. The SIGNAL unit **520** can further include a "Num SS" field indicating the number of spatial streams used. The "Num SS" field can be 2-bits long.

The SIGNAL unit **520** can further include an "SGI" field indicating the short guard interval (SGI) used. The "SGI" field can be 1-bit long. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 8 μs. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 4 μs.

The SIGNAL unit **520** can further include a "coding" field indicating the type of encoding used. The "coding" field can be 1-bit long. The SIGNAL unit **520** can further include an "MCS" field indicating the modulation coding scheme (MCS) used. The "MCS" field can be 4-bits long. If multi-user, some bits of the "MCS" field may be used to indicate coding for users 1-3. For example, the first, second, and third bits of the "MCS" field may be used to indicate coding for users 1, 2, and 3, respectively. In an embodiment, the "MCS" field may indicate that, for example, quadrature phase-shift keying (QPSK) is used. The SIGNAL unit **520** can further include an "aggregation" field indicating whether A-MPDU is being used. The "aggregation" field can be 1-bit long.

The SIGNAL unit **520** can further include a "length" field indicating length of the payload **530**. The "length" field can be 9-bits long. In an embodiment, the "length" field can indicate the length of the payload **530** in units of symbols when A-MPDU is being used. The "length" field can indicate the length of the payload **530** in units of bytes when A-MPDU is not being used. In an embodiment, A-MPDU is used for packed sizes greater than 511 bytes. The SIGNAL unit **520** can further include a Doppler/reserved bit, which may be used as a reserved bit or as a Doppler mitigation bit to signal to the receiver that there are sections in SIGNAL unit **520** which can enable the receiver to mitigate the impact of 'high temporal channel variation' during transmission of the SIGNAL unit **520**.

The SIGNAL unit **520** can further include a "CRC" field indicating the result of a cyclic redundancy check (CRC) computed on one or more fields of the SIGNAL unit **520**. The "CRC" field can be 4-bits long. In an embodiment, another error-detection code can be used instead of, or in addition to, the CRC. The SIGNAL unit **520** can omit a "tail" field used to reset the state of a convolution encoder and/or decoder, and for example, use tail biting, which is described more fully below.

In an embodiment, for a 2 MHz SIG packet with a short preamble, the SIGNAL unit **520** can include one or more of the fields shown below in Table 22. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length. In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 22. In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 22. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 22 in the order shown in Table 22. In some embodiments, at least a portion of the information of multiple fields shown in Table 22 is included in a single field. For example, the first and second fields of Table 22 may be collapsed into a single field including the information of both the first and second fields.

As discussed below, exceptional values in one or more of the fields shown in Table 22 may indicate that one or more fields of SIGNAL unit **520** should be interpreted differently. For example, when one field in the SIGNAL unit includes an exceptional state, one or more other fields of the SIGNAL unit **520** may include other information related to alternative frame type, such as an ACK frame, a beacon frame, a SYNC beacon frame, a link adaptation frame, etc. Other information can include synchronization information, beacon information, link adaptation information, acknowledgment information, etc. In general, a zero-length payload may be indicated by one or more fields in the SIGNAL unit **520** having an exceptional state.

In one embodiment, a value of all-zeros in the "length" field of the 2 MHz SIG packet may indicate that one or more of the reserved bits may indicate an alternative frame type. In another embodiment, a value of all-ones in the "MCS" field may indicate that the payload length is zero, and that one or more bits of the "length" field contains data related to an alternative frame type. In another embodiment, a non-zero value in one or more "reserved" bits may indicate that the payload length is zero, and that one or more bits of the "length" field contains data related to an alternative frame type. In some embodiments, exceptional values in the "length" field can indicate how the SIG field should be interpreted. In some embodiments, exceptional values in the "length" field can indicate the number of symbols of data following the PHY preamble, and optionally at what MCS the symbols are encoded. Exceptional values of the "length" field may include, for example, small lengths, such as 0, 1, 2, 3, or values less than, for example, 5 or 10.

TABLE 22

Field of SIG (2 MHz 2 symbols)	Bits
Reserved	1
STBC	1
Reserved	1
BW	2
Nsts	2
PAID	9
SGI	1
Coding	2
MCS	4
Smoothing	1
Aggregation	1
Length	9
ACK Indication	2
Reserved	2
CRC	4
Tail	6
Total	48

In the aspect shown in Table 22, the SIGNAL unit **520** can include a first "Reserved" field that may be one bit long. The SIGNAL unit **520** can further include an "STBC" field indi-

cating whether space-time block coding (STBC) is used. The "STBC" field can be 1-bit long. The SIGNAL unit **520** can further include a second "Reserved" field that may be one bit in length.

The SIGNAL unit **520** can further include a "BW" field indicating the bandwidth (BW) used. The "BW" field can be 2-bits long. In various embodiments, the 2-bit "BW" field can indicate whether the bandwidth is 2 MHz, 4 MHz, 8 MHz, or 16 MHz. The SIGNAL unit **520** can further include an "Nsts" field. The "Nsts" field may provide the number of space time streams (STS). The "Nsts" field may be two bits long.

The SIGNAL unit **520** can further include a "PAID" field indicating a partial association identifier associated with the data unit **500**. The "PAID" field can be 9-bits long. The SIGNAL unit **520** can further include an "SGI" field indicating the short guard interval (SGI) used. The "SGI" field can be 1-bit long. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 8 μs. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 4 μs.

The SIGNAL unit **520** can further include a "Coding" field indicating the type of encoding used. The "Coding" field can be 2-bit long. The SIGNAL unit **520** can further include an "MCS" field indicating the modulation coding scheme (MCS) used. The "MCS" field can be 4-bits long. If multi-user, some bits of the "MCS" field may be used to indicate coding for users 1-3. For example, the first, second, and third bits of the "MCS" field may be used to indicate coding for users 1, 2, and 3, respectively. In an embodiment, the "MCS" field may indicate that, for example, quadrature phase-shift keying (QPSK) is used. The SIGNAL unit **520** can further include a "Smoothing" field indicating whether smoothing is recommended on channel estimation. The "Smoothing" field can be one bit long. The SIGNAL unit **520** can further include an "aggregation" field indicating whether A-MPDU is being used. The "aggregation" field can be 1-bit long.

The SIGNAL unit **520** can further include a "length" field indicating length of the payload **530**. The "length" field can be 9-bits long. In an embodiment, the "length" field can indicate the length of the payload **530** in units of symbols when A-MPDU is being used. The "length" field can indicate the length of the payload **530** in units of bytes when A-MPDU is not being used. In an embodiment, A-MPDU is used for packed sizes greater than 511 bytes. The SIGNAL unit **520** can further include an "ACK Indication" field indicating whether the SIGNAL unit is an acknowledgment. In an embodiment, the "ACK Indication" field may indicate whether the SIGNAL unit **520** is an acknowledgement (0x00), a block acknowledgement (0x01), or not an acknowledgement (0x10). The value of (0x11) may be reserved. The "ACK Indication" field may be two bits in length. The SIGNAL unit may include a third "Reserved" field. The third "Reserved" field may be two bits in length.

The SIGNAL unit **520** can further include a "CRC" field indicating the result of a cyclic redundancy check (CRC) computed on one or more fields of the SIGNAL unit **520**. The "CRC" field can be 4-bits long. In an embodiment, another error-detection code can be used instead of, or in addition to, the CRC. The SIGNAL unit **520** can further include a "tail" field used to reset the state of a convolution encoder and/or decoder. The "tail" field can be 6-bits long.

In an embodiment, the first "Reserved" field, "STBC" field, second "Reserved" field, "BW" field, "Nsts" field, "PAID" field, "SGI" field, "Coding" field, "MCS" field, and the "Smoothing" field may be encoded using the first symbol of SIG-A. In an embodiment, the "Aggregation" field, "Length" field, "ACK Indication" field, third "Reserved" field, "CRC" field, and "Tail" field may be encoded using the second symbol of SIG-A.

In an embodiment, for a 2 MHz SIG-A packet with a long preamble and used for a single user, the SIGNAL unit **520** can include one or more of the fields shown below in Table 23. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length. In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 23. In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 23. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 23 in the order shown in Table 23. In some embodiments, at least a portion of the information of multiple fields shown in Table 23 is included in a single field. For example, the first and second fields of Table 23 may be collapsed into a single field including the information of both the first and second fields.

As discussed below, exceptional values in one or more of the fields shown in Table 23 may indicate that one or more fields of SIGNAL unit **520** should be interpreted differently. For example, when one field in the SIGNAL unit **520** includes an exceptional state, one or more other fields of the SIGNAL unit **520** may include other information related to alternative frame type, such as an ACK frame, a beacon frame, a SYNC beacon frame, a link adaptation frame, etc. Other information can include synchronization information, beacon information, link adaptation information, acknowledgment information, etc. In general, a zero-length payload may be indicated by one or more fields in the SIGNAL unit **520** having an exceptional state.

In one embodiment, a value of all-zeros in the "length" field of the 2 MHz SIG-A packet may indicate that one or more of the reserved bits may indicate an alternative frame type. In another embodiment, a value of all-ones in the "MCS" field may indicate that the payload length is zero, and that one or more bits of the "length" field contains data related to an alternative frame type. In another embodiment, a non-zero value in one or more "reserved" bits may indicate that the payload length is zero, and that one or more bits of the "length" field contains data related to an alternative frame type. In some embodiments, exceptional values in the "length" field can indicate how the SIG field should be interpreted. In some embodiments, exceptional values in the "length" field can indicate the number of symbols of data following the PHY preamble, and optionally at what MCS the symbols are encoded. Exceptional values of the "length" field may include, for example, small lengths, such as 0, 1, 2, 3, or values less than, for example, 5 or 10.

TABLE 23

Field of SIG-A (2 MHz 2 symbols)	Bits
MU/SU	1
STBC	1
Reserved	1
BW	2
Nsts	2
PAID	9
SGI	1
Coding	2
MCS	4
Beam-Change Indication	1
Aggregation	1
Length	9
ACK Indication	2

TABLE 23-continued

Field of SIG-A (2 MHz 2 symbols)	Bits
Reserved	2
CRC	4
Tail	6
Total	48

In the aspect shown in Table 23, the SIGNAL unit **520** can include a "MU/SU" field, indicating whether the SIGNAL unit is for a single user or multiple users. The "MU/SU" field may be one bit long. The "MU/SU" field may be set to zero for single user. The SIGNAL unit **520** can further include an "STBC" field indicating whether space-time block coding (STBC) is used. The "STBC" field can be 1-bit long. The SIGNAL unit **520** can further include a first "Reserved" field that may be one bit in length.

The SIGNAL unit **520** can further include a "BW" field indicating the bandwidth (BW) used. The "BW" field can be 2-bits long. In various embodiments, the 2-bit "BW" field can indicate whether the bandwidth is 2 MHz, 4 MHz, 8 MHz, or 16 MHz. The SIGNAL unit **520** can further include an "Nsts" field. The "Nsts" field may provide the number of space time streams (STS). The "Nsts" field may be two bits long. The SIGNAL unit **520** can further include a "PAID" field indicating a partial association identifier associated with the data unit **500**. The "PAID" field can be 9-bits long.

The SIGNAL unit **520** can further include an "SGI" field indicating the short guard interval (SGI) used. The "SGI" field can be 1-bit long. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 8 μs. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 4 μs.

The SIGNAL unit **520** can further include a "coding" field indicating the type of encoding used. The "coding" field can be 2 bits long. In an embodiment, the first bit of the "Coding" field is the coding type for single user, while the second bit is the coding type for LDPC Nsym ambiguity. The SIGNAL unit **520** can further include an "MCS" field indicating the modulation coding scheme (MCS) used. The "MCS" field can be 4-bits long. The "MCS" field may indicate coding for single-user. If multi-user, some bits of the "MCS" field may be used to indicate coding for users 1-3. For example, the first, second, and third bits of the "MCS" field may be used to indicate coding for users 1, 2, and 3, respectively. In an embodiment, the "MCS" field may indicate that, for example, quadrature phase-shift keying (QPSK) is used. The SIGNAL unit **520** can further include a "Beam-change indication" field indicating if a quadrature component matrix (Q matrix) changes starting data STF (D-STF). The "Beam-Change Indication" field can be one bit long. The SIGNAL unit **520** can further include an "Aggregation" field indicating whether an A-MPDU is being used. The "Aggregation" field can be 1-bit long.

The SIGNAL unit **520** can further include a "length" field indicating length of the payload **530**. The "length" field can be 9-bits long. In an embodiment, the "length" field can indicate the length of the payload **530** in units of symbols when A-MPDU is being used. The "length" field can indicate the length of the payload **530** in units of bytes when A-MPDU is not being used. In an embodiment, A-MPDU is used for packed sizes greater than 511 bytes. The SIGNAL unit **520** can further include an "ACK Indication" field indicating whether the SIGNAL unit is an acknowledgment. In an embodiment, the "ACK Indication" field may indicate whether the SIGNAL unit **520** is an acknowledgement (0×00), a block acknowledgement (0×01), or not an acknowledgement (0×10). The value of (0×11) may be reserved. The "ACK Indication" field may be two bits in length. The SIGNAL unit may include a second "Reserved" field. The "Reserved" field may be two bits in length.

The SIGNAL unit **520** can further include a "CRC" field indicating the result of a cyclic redundancy check (CRC) computed on one or more fields of the SIGNAL unit **520**. The "CRC" field can be 4-bits long. In an embodiment, another error-detection code can be used instead of, or in addition to, the CRC. The SIGNAL unit **520** can further include a "tail" field used to reset the state of a convolution encoder and/or decoder. The "tail" field can be 6-bits long.

In an embodiment, the "MU/SU" field, "STBC" field, first "Reserved" field, "BW" field, "Nsts" field, "PAID" field, "SGI" field, "Coding" field, "MCS" field, and "Beam-Change Indication" field may be encoded using the first symbol of SIG-A. In an embodiment, the "Aggregation" field, "Length" field, "ACK Indication" field, second "Reserved" field, "CRC" field, and "Tail" field may be encoded using the second symbol of SIG-A.

In an embodiment, for a 2 MHz SIG-A packet with a long preamble and used for multi-user, the SIGNAL unit **520** can include one or more of the fields shown below in Table 24. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length. In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 24. In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 24. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 24 in the order shown in Table 24. In some embodiments, at least a portion of the information of multiple fields shown in Table 24 is included in a single field. For example, the first and second fields of Table 24 may be collapsed into a single field including the information of both the first and second fields.

As discussed below, exceptional values in one or more of the fields shown in Table 24 may indicate that one or more fields of SIGNAL unit **520** should be interpreted differently. For example, when one field in the SIGNAL unit includes an exceptional state, one or more other fields of the SIGNAL unit **520** may include other information related to alternative frame type, such as an ACK frame, a beacon frame, a SYNC beacon frame, a link adaptation frame, etc. Other information can include synchronization information, beacon information, link adaptation information, acknowledgment information, etc. In general, a zero-length payload may be indicated by one or more fields in the SIGNAL unit **520** having an exceptional state.

In one embodiment, a value of all-zeros in the "length" field of the 2 MHz SIG-A packet may indicate that one or more of the reserved bits may indicate an alternative frame type. In another embodiment, a value of all-ones in the "MCS" field may indicate that the payload length is zero, and that one or more bits of the "length" field contains data related to an alternative frame type. In another embodiment, a non-zero value in one or more "reserved" bits may indicate that the payload length is zero, and that one or more bits of the "length" field contains data related to an alternative frame type. In some embodiments, exceptional values in the "length" field can indicate how the SIG field should be interpreted. In some embodiments, exceptional values in the "length" field can indicate the number of symbols of data following the PHY preamble, and optionally at what MCS the symbols are encoded. Exceptional values of the "length" field

may include, for example, small lengths, such as 0, 1, 2, 3, or values less than, for example, 5 or 10.

TABLE 24

Field of SIG-A (2 MHz 2 symbols)	Bits
MU/SU	1
STBC	1
Reserved	1
BW	2
Nsts	8
GID	6
SGI	1
Coding - I	4
Coding - II	1
Beam-Change Indication	1
Length	9
ACK Indication	2
Reserved	1
CRC	4
Tail	6
Total	48

In the aspect shown in Table 24, the SIGNAL unit **520** can include a "MU/SU" field, indicating whether the SIGNAL unit is for a single user or multiple users. The "MU/SU" field may be one bit long. The "MU/SU" field may be set to one for multi user. The SIGNAL unit **520** can further include an "STBC" field indicating whether space-time block coding (STBC) is used. The "STBC" field can be 1-bit long. The SIGNAL unit **520** can further include a first "Reserved" field that may be one bit in length.

The SIGNAL unit **520** can further include a "BW" field indicating the bandwidth (BW) used. The "BW" field can be 2-bits long. In various embodiments, the 2-bit "BW" field can indicate whether the bandwidth is 2 MHz, 4 MHz, 8 MHz, or 16 MHz. The SIGNAL unit **520** can further include an "Nsts" field. The "Nsts" field may provide the number of space time streams (STS). The "Nsts" field may be eight bits long. Two bits of the "Nsts" field may be provided per user for up to four users. The SIGNAL unit **520** can further include a "GID" field indicating a group identifier associated with the data unit **500**. The "GID" field can be 6-bits long.

The SIGNAL unit **520** can further include an "SGI" field indicating the short guard interval (SGI) used. The "SGI" field can be 1-bit long. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 8 μs. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 4 μs.

The SIGNAL unit **520** can further include a "Coding-I" field indicating the type of encoding used. The "Coding-I" field can be 4 bits long. Each bit may indicate a coding type for each of four users. The SIGNAL unit **520** can further include a "Coding-II" field, indicating LDPC Nsym ambiguity. The SIGNAL unit **520** can further include a "Beam-Change Indication" field indicating if a Q matrix changes starting D-STF. The "Beam-Change Indication" field can be one bit long.

The SIGNAL unit **520** can further include a "length" field indicating length of the payload **530**. The "length" field can be 9-bits long. In an embodiment, the "length" field can indicate the length of the payload **530** in units of symbols when A-MPDU is being used. The "length" field can indicate the length of the payload **530** in units of bytes when A-MPDU is not being used. In an embodiment, A-MPDU is used for packed sizes greater than 511 bytes. The SIGNAL unit **520** can further include an "ACK Indication" field indicating whether the SIGNAL unit is an acknowledgment. In an embodiment, the "ACK Indication" field may indicate whether the SIGNAL unit **520** is an acknowledgement (0x00), a block acknowledgement (0x 01), or not an acknowledgement (0x10). The value of (0x 11) may be reserved. The "ACK Indication" field may be two bits in length. The SIGNAL unit may include a second "Reserved" field. The "Reserved" field may be one bit in length.

The SIGNAL unit **520** can further include a "CRC" field indicating the result of a cyclic redundancy check (CRC) computed on one or more fields of the SIGNAL unit **520**. The "CRC" field can be 4-bits long. In an embodiment, another error-detection code can be used instead of, or in addition to, the CRC. The SIGNAL unit **520** can further include a "tail" field used to reset the state of a convolution encoder and/or decoder. The "tail" field can be 6-bits long.

In an embodiment, the "MU/SU" field, "STBC" field, first "Reserved" field, "BW" field, "Nsts" field, "GID" field, "SGI" field, and the "Coding-I" field may be encoded using the first symbol of SIG-A. In an embodiment, the "Coding-II" field, "Beam-Change Indication" field, "Length" field, "ACK Indication" field, second "Reserved" field, "CRC" field, and "Tail" field may be encoded using the second symbol of SIG-A.

In an embodiment, for a 1 MHz SIG packet, the SIGNAL unit **520** can include one or more of the fields shown below in Table 25. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length. In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 25. In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 25. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 25 in the order shown in Table 25. In some embodiments, at least a portion of the information of multiple fields shown in Table 25 is included in a single field. For example, the first and second fields of Table 25 may be collapsed into a single field including the information of both the first and second fields.

As discussed below, exceptional values in one or more of the fields shown in Table 25 may indicate that one or more fields of SIGNAL unit **520** should be interpreted differently. For example, when one field in the SIGNAL unit includes an exceptional state, one or more other fields of the SIGNAL unit **520** may include other information related to alternative frame type, such as an ACK frame, a beacon frame, a SYNC beacon frame, a link adaptation frame, etc. Other information can include synchronization information, beacon information, link adaptation information, acknowledgment information, etc. In general, a zero-length payload may be indicated by one or more fields in the SIGNAL unit **520** having an exceptional state.

In one embodiment, a value of all-zeros in the "length" field of the 1 MHz SIG packet may indicate that one or more of the reserved bits may indicate an alternative frame type. In another embodiment, a value of all-ones in the "MCS" field may indicate that the payload length is zero, and that one or more bits of the "length" field contains data related to an alternative frame type. In another embodiment, a non-zero value in one or more "reserved" bits may indicate that the payload length is zero, and that one or more bits of the "length" field contains data related to an alternative frame type. In some embodiments, exceptional values in the "length" field can indicate how the SIG field should be interpreted. In some embodiments, exceptional values in the "length" field can indicate the number of symbols of data following the PHY preamble, and optionally at what MCS the

symbols are encoded. Exceptional values of the "length" field may include, for example, small lengths, such as 0, 1, 2, 3, or values less than, for example, 5 or 10.

TABLE 25

Field of SIG (1 MHz 5 or 6 symbols)	Bits
Nsts	2
SGI	1
Coding	2
STBC	1
Reserved	1
MCS	4
Aggregation	1
Length	9
ACK Indication	2
Reserved	3
CRC	4
Tail	6
Total	36

In the aspect shown in Table 25, the SIGNAL unit **520** can include an "Nsts" field. The "Nsts" field may provide the number of space time streams (STS). The "Nsts" field may be two bits long. The SIGNAL unit **520** can further include an "SGI" field indicating the short guard interval (SGI) used. The "SGI" field can be 1-bit long. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 8 μs. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 4 μs.

The SIGNAL unit **520** can further include a "Coding" field indicating the type of encoding used. The "Coding" field can be 2 bits long. One bit may indicate a coding type (LDPC/BCC). The second bit may indicate LDPC N_{sym} ambiguity. The SIGNAL unit **520** can further include an "STBC" field indicating whether space-time block coding (STBC) is used. The "STBC" field can be 1-bit long. The SIGNAL unit **520** can further include a first "Reserved" field that may be one bit in length.

The SIGNAL unit **520** can further include an "MCS" field indicating the modulation coding scheme (MCS) used. The "MCS" field can be 4-bits long. In an embodiment, the "MCS" field may indicate that, for example, quadrature phase-shift keying (QPSK) is used. The SIGNAL unit **520** can further include an "Aggregation" field indicating whether an A-MPDU is being used. The "Aggregation" field can be 1-bit long.

The SIGNAL unit **520** can further include a "length" field indicating length of the payload **530**. The "length" field can be 9-bits long. In an embodiment, the "length" field can indicate the length of the payload **530** in units of symbols when A-MPDU is being used. The "length" field can indicate the length of the payload **530** in units of bytes when A-MPDU is not being used. In an embodiment, A-MPDU is used for packed sizes greater than 511 bytes. The SIGNAL unit **520** can further include an "ACK Indication" field indicating whether the SIGNAL unit is an acknowledgment. In an embodiment, the "ACK Indication" field may indicate whether the SIGNAL unit **520** is an acknowledgement (0x00), a block acknowledgement (0x01), or not an acknowledgement (0x10). The value of (0x11) may be reserved. The "ACK Indication" field may be two bits in length. The SIGNAL unit may include a second "Reserved" field. The "Reserved" field may be three bits in length.

The SIGNAL unit **520** can further include a "CRC" field indicating the result of a cyclic redundancy check (CRC) computed on one or more fields of the SIGNAL unit **520**. The "CRC" field can be 4-bits long. In an embodiment, another error-detection code can be used instead of, or in addition to, the CRC. The SIGNAL unit **520** can further include a "tail" field used to reset the state of a convolution encoder and/or decoder. The "tail" field can be 6-bits long.

In an embodiment, one reserved bit is placed just after the first symbol. This may provision new PHY features. This provides a total of four (4) reserved bits.

In an embodiment, for a 2 MHz SIG packet with a short preamble, the SIGNAL unit **520** can include one or more of the fields shown below in Table 26. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length.

The ordering of the fields may affect the peak to average power ratio of receiving or transmitting or generating the packet. Therefore, in some embodiments, the ordering of the fields may be changed to reduce the peak to average power ratio experienced when receiving or transmitting or generating the packet. The peak to average power ratio for a packet with the fields and field order shown in Table 26 has been measured. The measurements show a peak to average power ratio of 11.59 decibels for the first symbol and 9.86 decibels for the second symbol when the reserved bits are set to one (1). When the reserved bits are set to zero, experimental results have shown a peak to average power ratio of 13.4845 decibels for the first symbol and 10.4742 decibels for the second symbol when the reserved bits are set to zero (0).

In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 26. In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 26. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 26 in the order shown in Table 26. In some embodiments, at least a portion of the information of multiple fields shown in Table 26 is included in a single field. For example, the first and second fields of Table 26 may be collapsed into a single field including the information of both the first and second fields.

As discussed below, exceptional values in one or more of the fields shown in Table 26 may indicate that one or more fields of SIGNAL unit **520** should be interpreted differently. For example, when one field in the SIGNAL unit includes an exceptional state, one or more other fields of the SIGNAL unit **520** may include other information related to alternative frame type, such as an ACK frame, a beacon frame, a SYNC beacon frame, a link adaptation frame, etc. Other information can include synchronization information, beacon information, link adaptation information, acknowledgment information, etc. In general, a zero-length payload may be indicated by one or more fields in the SIGNAL unit **520** having an exceptional state.

In one embodiment, a value of all-zeros in the "length" field of the 2 MHz SIG packet may indicate that one or more of the reserved bits may indicate an alternative frame type. In another embodiment, a value of all-ones in the "MCS" field may indicate that the payload length is zero, and that one or more bits of the "length" field contains data related to an alternative frame type. In another embodiment, a non-zero value in one or more "reserved" bits may indicate that the payload length is zero, and that one or more bits of the "length" field contains data related to an alternative frame type. In some embodiments, exceptional values in the "length" field can indicate how the SIG field should be interpreted. In some embodiments, exceptional values in the "length" field can indicate the number of symbols of data following the PHY preamble, and optionally at what MCS the symbols are encoded. Exceptional values of the "length" field

may include, for example, small lengths, such as 0, 1, 2, 3, or values less than, for example, 5 or 10.

TABLE 26

Field of SIG (2 MHz 2 symbols)	Bits
Reserved	1
STBC	1
Reserved	1
BW	2
Nsts	2
Length	9
SGI	1
Coding	2
MCS	4
Smoothing	1
Aggregation	1
PAID	9
ACK Indication	2
Reserved	2
CRC	4
Tail	6
Total	48

In the aspect shown in Table 26, the SIGNAL unit **520** can include a first "Reserved" field that may be one bit long. The SIGNAL unit **520** can further include an "STBC" field indicating whether space-time block coding (STBC) is used. The "STBC" field can be 1-bit long. The SIGNAL unit **520** can further include a second "Reserved" field that may be one bit in length.

The SIGNAL unit **520** can further include a "BW" field indicating the bandwidth (BW) used. The "BW" field can be 2-bits long. In various embodiments, the 2-bit "BW" field can indicate whether the bandwidth is 2 MHz, 4 MHz, 8 MHz, or 16 MHz.

The SIGNAL unit **520** can further include an "Nsts" field. The "Nsts" field may provide the number of space time streams (STS). The "Nsts" field may be two bits long.

The SIGNAL unit **520** can further include a "length" field indicating length of the payload **530**. The "length" field can be 9-bits long. In an embodiment, the "length" field can indicate the length of the payload **530** in units of symbols when A-MPDU is being used. The "length" field can indicate the length of the payload **530** in units of bytes when A-MPDU is not being used. In an embodiment, A-MPDU is used for packed sizes greater than 511 bytes. The SIGNAL unit **520** can further include an "SGI" field indicating the short guard interval (SGI) used. The "SGI" field can be 1-bit long. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 8 μs. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 4 μs.

The SIGNAL unit **520** can further include a "Coding" field indicating the type of encoding used. The "Coding" field can be 2-bit long. The SIGNAL unit **520** can further include an "MCS" field indicating the modulation coding scheme (MCS) used. The "MCS" field can be 4-bits long. If multi-user, some bits of the "MCS" field may be used to indicate coding for users 1-3. For example, the first, second, and third bits of the "MCS" field may be used to indicate coding for users 1, 2, and 3, respectively. In an embodiment, the "MCS" field may indicate that, for example, quadrature phase-shift keying (QPSK) is used. The SIGNAL unit **520** can further include a "Smoothing" field indicating whether smoothing is recommended on channel estimation. The "Smoothing" field can be one bit long. The SIGNAL unit **520** can further include an "aggregation" field indicating whether A-MPDU is being used. The "aggregation" field can be 1-bit long.

The SIGNAL unit **520** can further include a "PAID" field indicating a partial association identifier associated with the data unit **500**. The "PAID" field can be 9-bits long. The SIGNAL unit **520** can further include an "ACK Indication" field indicating whether the SIGNAL unit is an acknowledgment. In an embodiment, the "ACK Indication" field may indicate whether the SIGNAL unit **520** is an acknowledgement (0x00), a block acknowledgement (0x01), or not an acknowledgement (0x10). The value of (0x11) may be reserved. The "ACK Indication" field may be two bits in length. The SIGNAL unit may include a third "Reserved" field. The third "Reserved" field may be two bits in length.

The SIGNAL unit **520** can further include a "CRC" field indicating the result of a cyclic redundancy check (CRC) computed on one or more fields of the SIGNAL unit **520**. The "CRC" field can be 4-bits long. In an embodiment, another error-detection code can be used instead of, or in addition to, the CRC. The SIGNAL unit **520** can further include a "tail" field used to reset the state of a convolution encoder and/or decoder. The "tail" field can be 6-bits long.

In an embodiment, the first "Reserved" field, "STBC" field, second "Reserved" field, "BW" field, "Nsts" field, "Length" field, "SGI" field, "Coding" field, "MCS" field, and the "Smoothing" field may be encoded using the first symbol of SIG-A. In an embodiment, the "Aggregation" field, "PAID" field, "ACK Indication" field, third "Reserved" field, "CRC" field, and "Tail" field may be encoded using the second symbol of SIG-A.

In an embodiment, one reserved bit is placed in the first symbol. This may provision new PHY features.

In an embodiment, generating or receiving a first symbol of a 2 MHz, short preamble SIG field with fields ordered as shown in Table 26 may provide a maximum peak to average power ratio (PAPR) of less than 7.1 decibels. This PAPR may be measured using open loop transmission, a 256 byte packet, aggregation off, the ACK Indication field set to ACK, one stream, MCS0 and MCS7. All combinations of the remaining unspecified fields may be considered when determining this PAPR. The CRC field uses the four least significant bits (LSB) of the regular 8-bit CRC field in 802.11n or 802.11ac. QBPSK modulation is used on both SIG symbols. 4× oversampled IFFT is also used. The stated maximum PAPR value above was determined by measuring the PAPR over all combinations of the unspecified fields.

In an embodiment, for a 2 MHz SIG-A packet with a long preamble and used for a single user, the SIGNAL unit **520** can include one or more of the fields shown below in Table 27. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length.

The ordering of the fields may affect the peak to average power ratio of receiving or transmitting or generating the packet. Therefore, in some embodiments, the ordering of the fields may be changed to reduce the peak to average power ratio experienced when receiving or transmitting or generating the packet. The peak to average power ratio for a packet with the fields and field order shown in Table 27 has been measured. The measurements show a peak to average power ratio of 11.1304 decibels for the first symbol and 10.4442 decibels for the second symbol when the reserved bits are set to one (1). When the reserved bits are set to zero, experimental results have shown a peak to average power ratio of 13.4845 decibels for the first symbol and 8.8606 decibels for the second symbol when the reserved bits are set to zero (0).

In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 27. In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 27. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 27 in the order shown in Table 27. In some embodiments, at least a portion of the information of multiple fields shown in Table 27 is included in a single field. For example, the first and second fields of Table 27 may be collapsed into a single field including the information of both the first and second fields.

As discussed below, exceptional values in one or more of the fields shown in Table 27 may indicate that one or more fields of SIGNAL unit **520** should be interpreted differently. For example, when one field in the SIGNAL unit includes an exceptional state, one or more other fields of the SIGNAL unit **520** may include other information related to alternative frame type, such as an ACK frame, a beacon frame, a SYNC beacon frame, a link adaptation frame, etc. Other information can include synchronization information, beacon information, link adaptation information, acknowledgment information, etc. In general, a zero-length payload may be indicated by one or more fields in the SIGNAL unit **520** having an exceptional state.

In one embodiment, a value of all-zeros in the "length" field of the 2 MHz SIG-A packet may indicate that one or more of the reserved bits may indicate an alternative frame type. In another embodiment, a value of all-ones in the "MCS" field may indicate that the payload length is zero, and that one or more bits of the "length" field contains data related to an alternative frame type. In another embodiment, a non-zero value in one or more "reserved" bits may indicate that the payload length is zero, and that one or more bits of the "length" field contains data related to an alternative frame type. In some embodiments, exceptional values in the "length" field can indicate how the SIG field should be interpreted. In some embodiments, exceptional values in the "length" field can indicate the number of symbols of data following the PHY preamble, and optionally at what MCS the symbols are encoded. Exceptional values of the "length" field may include, for example, small lengths, such as 0, 1, 2, 3, or values less than, for example, 5 or 10.

TABLE 27

Field of SIG-A (2 MHz 2 symbols)	Bits
MU/SU	1
STBC	1
Reserved	1
BW	2
Nsts	2
Length	9
SGI	1
Coding	2
MCS	4
Beam-Change Indication	1
Aggregation	1
PAID	9
ACK Indication	2
Reserved	2
CRC	4
Tail	6
Total	48

In the aspect shown in Table 27, the SIGNAL unit **520** can include a "MU/SU" field, indicating whether the SIGNAL unit is for a single user or multiple users. The "MU/SU" field may be one bit long. The "MU/SU" field may be set to zero for single user. The SIGNAL unit **520** can further include an "STBC" field indicating whether space-time block coding (STBC) is used. The "STBC" field can be 1-bit long. The SIGNAL unit **520** can further include a first "Reserved" field that may be one bit in length.

The SIGNAL unit **520** can further include a "BW" field indicating the bandwidth (BW) used. The "BW" field can be 2-bits long. In various embodiments, the 2-bit "BW" field can indicate whether the bandwidth is 2 MHz, 4 MHz, 8 MHz, or 16 MHz. The SIGNAL unit **520** can further include an "Nsts" field. The "Nsts" field may provide the number of space time streams (STS). The "Nsts" field may be two bits long.

The SIGNAL unit **520** can further include a "length" field indicating length of the payload **530**. The "length" field can be 9-bits long. In an embodiment, the "length" field can indicate the length of the payload **530** in units of symbols when A-MPDU is being used. The "length" field can indicate the length of the payload **530** in units of bytes when A-MPDU is not being used. In an embodiment, A-MPDU is used for packed sizes greater than 511 bytes.

The SIGNAL unit **520** can further include an "SGI" field indicating the short guard interval (SGI) used. The "SGI" field can be 1-bit long. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 8 μs. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 4 μs.

The SIGNAL unit **520** can further include a "coding" field indicating the type of encoding used. The "coding" field can be 2 bits long. In an embodiment, the first bit of the "Coding" field is the coding type for single user, while the second bit is the coding type for LDPC Nsym ambiguity. The SIGNAL unit **520** can further include an "MCS" field indicating the modulation coding scheme (MCS) used. The "MCS" field can be 4-bits long. The "MCS" field may indicate coding for single-user. If multi-user, some bits of the "MCS" field may be used to indicate coding for users 1-3. For example, the first, second, and third bits of the "MCS" field may be used to indicate coding for users 1, 2, and 3, respectively. In an embodiment, the "MCS" field may indicate that, for example, quadrature phase-shift keying (QPSK) is used. The SIGNAL unit **520** can further include a "Beam-change indication" field indicating if a Q matrix changes starting D-STF. The "Beam-Change Indication" field can be one bit long. The SIGNAL unit **520** can further include an "Aggregation" field indicating whether an A-MPDU is being used. The "Aggregation" field can be 1-bit long.

The SIGNAL unit **520** can further include a "PAID" field indicating a partial association identifier associated with the data unit **500**. The "PAID" field can be 9-bits long.

The SIGNAL unit **520** can further include an "ACK Indication" field indicating whether the SIGNAL unit is an acknowledgment. In an embodiment, the "ACK Indication" field may indicate whether the SIGNAL unit **520** is an acknowledgement (0x00), a block acknowledgement (0x01), or not an acknowledgement (0x10). The value of (0×11) may be reserved. The "ACK Indication" field may be two bits in length. The SIGNAL unit may include a second "Reserved" field. The "Reserved" field may be two bits in length.

The SIGNAL unit **520** can further include a "CRC" field indicating the result of a cyclic redundancy check (CRC) computed on one or more fields of the SIGNAL unit **520**. The "CRC" field can be 4-bits long. In an embodiment, another error-detection code can be used instead of, or in addition to, the CRC. The SIGNAL unit **520** can further include a "tail" field used to reset the state of a convolution encoder and/or decoder. The "tail" field can be 6-bits long.

In an embodiment, the "MU/SU" field, "STBC" field, first "Reserved" field, "BW" field, "Nsts" field, "Length" field,

"SGI" field, "Coding" field, "MCS" field, and "Beam-Change Indication" field may be encoded using the first symbol of SIG-A. In an embodiment, the "Aggregation" field, "PAID" field, "ACK Indication" field, second "Reserved" field, "CRC" field, and "Tail" field may be encoded using the second symbol of SIG-A.

In an embodiment, generating or receiving a first symbol of a 2 MHz long preamble single-user SIG-A field with fields ordered as described in Table 27 may result in a maximum peak to average power ratio that is lower than 8.7 decibels. This PAPR may be measured using single user BF transmission, a 256 byte packet, aggregation off, the ACK Indication field set to ACK, one stream, and MCS7. All combinations of the remaining unspecified fields may be considered when determining this PAPR. The CRC field uses the four least significant bits (LSB) of the regular 8-bit CRC field in 802.11n or 802.11ac. QBPSK modulation is used on both SIG symbols. 4× oversampled IFFT is also used. The maximum PAPR value above was determined by measuring the PAPR over all combinations of the unspecified fields.

In an embodiment, for a 2 MHz SIG-A packet with a long preamble and used for multi-user, the SIGNAL unit **520** can include one or more of the fields shown below in Table 28. Although the fields are shown having a particular length, and in a particular order, in various embodiments, one or more fields may be rearranged, added, omitted, or may have a different length. In some embodiments, the SIGNAL unit **520** has all of the fields shown in Table 28.

The ordering of the fields may affect the peak to average power ratio of receiving or transmitting or generating the packet. Therefore, in some embodiments, the ordering of the fields may be changed to reduce the peak to average power ratio experienced when receiving or transmitting or generating the packet. The peak to average power ratio for a packet with the fields and field order shown in Table 28 has been measured. The measurements show a peak to average power ratio of 11.8997 decibels for the first symbol and 11.014 decibels for the second symbol when the reserved bits are set to one (1). When the reserved bits are set to zero, experimental results have shown a peak to average power ratio of 10.6865 decibels for the first symbol and 11.8570 decibels for the second symbol when the reserved bits are set to zero (0).

In some embodiments, the SIGNAL unit **520** has only the fields shown in Table 28. In some embodiments, the SIGNAL unit **520** has the fields shown in Table 28 in the order shown in Table 28. In some embodiments, at least a portion of the information of multiple fields shown in Table 28 is included in a single field. For example, the first and second fields of Table 28 may be collapsed into a single field including the information of both the first and second fields.

As discussed below, exceptional values in one or more of the fields shown in Table 28 may indicate that one or more fields of SIGNAL unit **520** should be interpreted differently. For example, when one field in the SIGNAL unit includes an exceptional state, one or more other fields of the SIGNAL unit **520** may include other information related to alternative frame type, such as an ACK frame, a beacon frame, a SYNC beacon frame, a link adaptation frame, etc. Other information can include synchronization information, beacon information, link adaptation information, acknowledgment information, etc. In general, a zero-length payload may be indicated by one or more fields in the SIGNAL unit **520** having an exceptional state.

In one embodiment, a value of all-zeros in the "length" field of the 2 MHz SIG-A packet may indicate that one or more of the reserved bits may indicate an alternative frame type. In another embodiment, a value of all-ones in the "MCS" field may indicate that the payload length is zero, and that one or more bits of the "length" field contains data related to an alternative frame type. In another embodiment, a non-zero value in one or more "reserved" bits may indicate that the payload length is zero, and that one or more bits of the "length" field contains data related to an alternative frame type. In some embodiments, exceptional values in the "length" field can indicate how the SIG field should be interpreted. In some embodiments, exceptional values in the "length" field can indicate the number of symbols of data following the PHY preamble, and optionally at what MCS the symbols are encoded. Exceptional values of the "length" field may include, for example, small lengths, such as 0, 1, 2, 3, or values less than, for example, 5 or 10.

TABLE 28

Field of SIG-A (2 MHz 2 symbols)	Bits
MU/SU	1
STBC	1
Reserved	1
Nsts	8
BW	2
GID	6
SGI	1
Coding - I	4
Coding - II	1
Beam-Change Indication	1
Length	9
Ack Indication	2
Reserved	1
CRC	4
Tail	6
Total	48

In the aspect shown in Table 28, the SIGNAL unit **520** can include a "MU/SU" field, indicating whether the SIGNAL unit is for a single user or multiple users. The "MU/SU" field may be one bit long. The "MU/SU" field may be set to one for multi user. The SIGNAL unit **520** can further include an "STBC" field indicating whether space-time block coding (STBC) is used. The "STBC" field can be 1-bit long. The SIGNAL unit **520** can further include a first "Reserved" field that may be one bit in length.

The SIGNAL unit **520** can further include an "Nsts" field. The "Nsts" field may provide the number of space time streams (STS). The "Nsts" field may be eight bits long. Two bits of the "Nsts" field may be provided per user for up to four users. The SIGNAL unit **520** can further include a "BW" field indicating the bandwidth (BW) used. The "BW" field can be 2-bits long. In various embodiments, the 2-bit "BW" field can indicate whether the bandwidth is 2 MHz, 4 MHz, 8 MHz, or 16 MHz. The SIGNAL unit **520** can further include a "GID" field indicating a group identifier associated with the data unit **500**. The "GID" field can be 6-bits long.

The SIGNAL unit **520** can further include an "SGI" field indicating the short guard interval (SGI) used. The "SGI" field can be 1-bit long. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 8 μs. In some embodiments, a short guard interval may be 2 μs and a normal guard interval may be 4 μs.

The SIGNAL unit **520** can further include a "Coding-I" field indicating the type of encoding used. The "Coding-I" field can be 4 bits long. Each bit may indicate a coding type for each of four users. The SIGNAL unit **520** can further include a "Coding-II" field, indicating LDPC Nsym ambiguity. The SIGNAL unit **520** can further include a "Beam-

Change Indication" field indicating if a Q matrix changes starting D-STF. The "Beam-Change Indication" field can be one bit long.

The SIGNAL unit **520** can further include a "length" field indicating length of the payload **530**. The "length" field can be 9-bits long. In an embodiment, the "length" field can indicate the length of the payload **530** in units of symbols when A-MPDU is being used. The "length" field can indicate the length of the payload **530** in units of bytes when A-MPDU is not being used. In an embodiment, A-MPDU is used for packed sizes greater than 511 bytes. The SIGNAL unit **520** can further include an "ACK Indication" field indicating whether the SIGNAL unit is an acknowledgment. In an embodiment, the "ACK Indication" field may indicate whether the SIGNAL unit **520** is an acknowledgement (0×00), a block acknowledgement (0×01), or not an acknowledgement (0×10). The value of (0×11) may be reserved. The "ACK Indication" field may be two bits in length. The SIGNAL unit may include a second "Reserved" field. The "Reserved" field may be one bit in length.

The SIGNAL unit **520** can further include a "CRC" field indicating the result of a cyclic redundancy check (CRC) computed on one or more fields of the SIGNAL unit **520**. The "CRC" field can be 4-bits long. In an embodiment, another error-detection code can be used instead of, or in addition to, the CRC. The SIGNAL unit **520** can further include a "tail" field used to reset the state of a convolution encoder and/or decoder. The "tail" field can be 6-bits long.

In an embodiment, the "MU/SU" field, "STBC" field, first "Reserved" field, "BW" field, "Nsts" field, "GID" field, "SGI" field, and the "Coding-I" field may be encoded using the first symbol of SIG-A. In an embodiment, the "Coding-II" field, "Beam-Change Indication" field, "Length" field, "ACK Indication" field, second "Reserved" field, "CRC" field, and "Tail" field may be encoded using the second symbol of SIG-A.

In an embodiment, generating or receiving a second symbol of an 8 MHz long preamble multi-user SIG field with fields ordered as described in Table 28 may result in a maximum peak to average power ratio (PAPR) that is lower than 11.1 decibels. This PAPR may be measured using multi-user transmission with three users. The group ID is set to three (3). A 1500 byte packet is used, with the ACK Indication field is set to block ACK (BA), one stream per user, and MCS7. All combinations of the remaining unspecified fields may be considered when determining this maximum PAPR. The CRC field uses the four least significant bits (LSB) of the regular 8-bit CRC field in 802.11n or 802.11ac. QBPSK modulation is used on both SIG symbols. 4× oversampled IFFT is also used. The stated maximum PAPR value is determined by measuring the PAPR over all combinations of the unspecified fields.

Because each of the seven symbols of the SIGNAL unit **520** is represented by a BPSK constellation having a rotation state which is either on the real or on the imaginary axis, the rotation state of each of the symbols can communicate an additional bit of information. For example, if the first symbol is on the real axis, this may communicate that STBC is on. Any of the bits of the SIGNAL unit **520** may be communicated through symbol rotation state. In the example shown in Table 28, at least one bit is communicated through rotation state of one of the symbols. In some embodiments, up to six reserved bits may be communicated through symbol rotation state. The reserved bits communicated through symbol rotation state may be 1^{st} reserved bits, 2^{nd} reserved bits, or a combination of 1^{st} and 2^{nd} reserved bits. In some embodiments, for robustness a single bit may be communicated by the rotation state of multiple symbols.

As discussed below, in various embodiments, the reserved bits can be used to carry additional information for different packet types. For example, the reserved bits can include additional information related to acknowledgement (ACK) packets. In some embodiments, the reserved bits can be used to extend the preceding field. For example, in the example shown in Table 19, one or more of the reserved bits may be used as additional bits for the "AID" field. In some embodiments, one or more of the reserved bits are used as one or more Doppler mitigation bits to signal to the receiver that there are sections in SIGNAL unit **520** which can enable the receiver to mitigate the impact of 'high temporal channel variation' during transmission of the SIGNAL unit **520**.

In various embodiments, one or more fields in the SIGNAL unit **520** can include one or more "exceptional" states or values. An exceptional state can include, for example, a field value that would not normally occur. For example, if the value of the "MCS" field can normally be either "00," "01," or "10," then the value of all-ones (e.g., "11") may be considered an exceptional state. As another example, a value of all-zeros in the "length" field may be an exceptional state. As another example, a non-zero value in any of the "reserved" bits may be an exceptional state.

Exceptional field states may indicate that one or more fields of the SIGNAL unit **520** should be interpreted differently. For example, when one field in the SIGNAL unit includes an exceptional state, one or more other fields of the SIGNAL unit **520** may include other information related to alternative frame type, such as an ACK frame, a beacon frame, a SYNC beacon frame, a link adaptation frame, etc. Other information can include synchronization information, beacon information, link adaptation information, acknowledgment information, etc. In general, a zero-length payload may be indicated by one or more fields in the SIGNAL unit **520** having an exceptional state.

In one embodiment, a value of all-zeros in the "length" field may indicate that one or more of the reserved bits may indicate an alternative frame type. In another embodiment, a value of all-ones in the "MCS" field may indicate that the payload length is zero, and that one or more bits of the "length" field contains data related to an alternative frame type. In another embodiment, a non-zero value in one or more "reserved" bits may indicate that the payload length is zero, and that one or more bits of the "length" field contains data related to an alternative frame type. In some embodiments, exceptional values in the "length" field can indicate how the SIG field should be interpreted. In some embodiments, exceptional values in the "length" field can indicate the number of symbols of data following the PHY preamble, and optionally at what MCS the symbols are encoded. Exceptional values of the "length" field may include, for example, small lengths, such as 0, 1, 2, 3, or values less than, for example, 5 or 10.

In some embodiments, an exceptional value in the "reserved" bits indicates whether an ACK packet follows the current frame. In some implementations, the "reserved" bits can indicate that the current frame is a control frame, and that the remaining bits are reserved for MAC indications, including length.

TABLE 29

SIG field for short format preamble, 2 MHz and higher

Field of SIG (short format, 2 MHz+)	Bits	Description
Reserved	1	
STBC	1	Alamouti like STBC on all or no streams
Reserved	1	
BW	2	Indicating BW mode (2, 4, 8, or 16)
Nsts	2	
Length	9	Dual Interpretation based on Agg. bit
SGI	1	Short Guard Interval
Coding	2	1^{st} bit for coding type, 2^{nd} bit for LDPC Nsym ambiguity
MCS	4	
Smoothing	1	Indicates Whether beamforming steering matrix applied to waveform
Aggregation bit	1	
PAID	9	
ACK Indication	2	00 = Ack; 01 = BA; 10 = No Ack; 11 = reserved
Reserved	2	
CRC	4	
Tail	6	
Total	48	

Table 29 illustrates an example of a SIG field that may be used in a short format preamble in bandwidth modes of 2 MHz or higher. The first ten fields of the SIG field (i.e., Reserved, STBC, Reserved, BW, Nsts, Length, SGI, Coding, MCS, and Smoothing) may be in a first symbol of the SIG field and the last six fields of the SIG field (i.e., Aggregation bit, PAID, ACK Indication, Reserved, CRC, and Tail) may be in a second symbol of the SIG field. In a particular embodiment, at least one reserved bit may be included in the first symbol of the SIG field to provision for a subsequently developed PHY feature.

TABLE 30

SIG-A field for long format preamble, 2 MHz and higher, SU

Field of SIG-A (long format, 2 MHz+, SU)	Bits	Description
MU/SU bit	1	Set to 0 for SU
STBC	1	Alamouti like STBC on all or no streams
Reserved	1	
BW	2	Indicating BW mode (2, 4, 8, or 16)
Nsts	2	
Length	9	Dual Interpretation based on Agg. bit
SGI	1	Short Guard Interval
Coding	2	1^{st} bit for coding type, 2^{nd} bit for LDPC Nsym ambiguity
MCS	4	
Beam-change indication bit	1	Whether Q matrix changes starting D-STF
Aggregation bit	1	
PAID	9	
ACK Indication	2	00 = Ack; 01 = BA; 10 = No Ack; 11 = reserved
Reserved	2	
CRC	4	
Tail	6	
Total	48	

Table 30 illustrates an example of a SIG-A field that may be used in a long format preamble in bandwidth modes of 2 MHz or higher for single user (SU) transmissions. The first ten fields of the SIG-A field (i.e., MU/SU bit, STBC, Reserved, BW, Nsts, Length, SGI, Coding, MCS, and Beam-change indication bit) may be in a first symbol of the SIG-A field and the last six fields of the SIG-A field (i.e., Aggregation bit, PAID, ACK Indication, Reserved, CRC, and Tail) may be in a second symbol of the SIG-A field.

TABLE 31

SIG-A field for long format preamble, 2 MHz and higher, MU

Field of SIG-A (long format, 2 MHz+, MU)	Bits	Description
MU/SU bit	1	Set to 1 for MU
STBC	1	Alamouti like STBC on all or no streams
Reserved	1	
Nsts	8	2 bits per use for each of 4 users
BW	2	Indicating BW mode (2, 4, 8, or 16)
GID	6	
SGI	1	Short Guard Interval
Coding-I	4	Coding type for each of 4 users
Coding-II	1	For LDPC Nsym ambiguity
Reserved	1	
Length	9	Interpreted as number of symbols in MU case
ACK Indication	2	00 = Ack; 01 = BA; 10 = No Ack; 11 = reserved
Reserved	1	
CRC	4	
Tail	6	
Total	48	

Table 31 illustrates an example of a SIG-A field that may be used in a long format preamble in bandwidth modes of 2 MHz or higher for multi user (MU) transmissions (e.g., for up to four users). The first eight fields of the SIG-A field (i.e., MU/SU bit, STBC, Reserved, Nsts, BW, GID, SGI, and Coding-I) may be in a first symbol of the SIG-A field and the last seven fields of the SIG-A field (i.e., Coding-II, Reserved, Length, ACK Indication, Reserved, CRC, and Tail) may be in a second symbol of the SIG-A field. It will be noted that the order of the Nsts and BW fields may be reversed as compared to the SU SIG-A field shown in Table 30. This reversal may lead to improved peak to average power ratio (PAPR) for the MU SIG-A field shown in Table 31.

TABLE 32

SIG field for 1 MHz mode

Field of SIG (1 MHz)	Bits	Description
Nsts	2	Number of space time streams
SGI	1	Short Guard Interval
Coding	2	1^{st} bit for coding type (LDPC/BCC), 2^{nd} bit for LDPC Nsym ambig.
STBC	1	
Reserved	1	
MCS	4	
Aggregation Bit	1	Whether A-MPDUs are in use
Length	9	Dual interpretation based on Agg. bit
ACK Indication	2	00 = Ack; 01 = BA; 10 = No Ack; 11 = reserved
Reserved	3	
CRC	4	
Tail	6	
Total	36	

Table 32 illustrates an example of a SIG field that may be used in 1 MHz transmissions. In a particular embodiment, the SIG field of Table 32 occupies six symbols (36 bits with 6 bits/symbol at 1 MHz bandwidth).

FIG. **6** shows a flow chart of an aspect of an exemplary method **600** of generating and transmitting a data unit. The

method **600** may be used to generate any of the data units and SIGNAL units described above. The data units may be generated at either an AP or a STA and transmitted to another device in the wireless network. Although the method **600** is described below with respect to elements of the wireless device **202***a* (FIG. **3**), those having ordinary skill in the art will appreciate that other components may be used to implement one or more of the steps described herein. Although steps may be described as occurring in a certain order, the steps can be reordered, steps can be omitted, and/or additional steps can be added.

At **602**, the processor **204** generates a SIGNAL unit **520**. The SIGNAL unit **520** includes at least an encoded PAID field. The PAID field has a value indicating that a portion of the signal unit is to be decoded by one or more devices which receive the signal unit, and the value of the PAID field indicates that the portion of the signal unit is not to be decoded by one or more other devices which receive the signal unit. In an embodiment, the modulator **302** may modulate a transmission that includes the SIGNAL unit **520**, and the transform module **304** may translate tones corresponding to the transmission into the time domain. Advancing to **604**, the transmitter **210** transmits a data unit including the SIGNAL unit over a wireless channel.

FIG. **7** shows a flow chart of another aspect of an exemplary method **700** of receiving and processing a data unit including a SIGNAL unit **520**. The method **700** may be used to receive any of the data units described above. The packets may be received at either an AP or a STA from another device in the wireless network. Although the method **700** is described below with respect to elements of the wireless device **202***b* (FIG. **4**), those having ordinary skill in the art will appreciate that other components may be used to implement one or more of the steps described herein. Although steps may be described as occurring in a certain order, the steps can be reordered, steps can be omitted, and/or additional steps can be added.

At **702**, the receiver **212** receives a SIGNAL unit **520**. The SIGNAL unit **520** includes at least an encoded PAID field. For example, the SIGNAL unit **520** can include one or more of the fields shown above in Tables 1-28. Advancing to **704**, the processor **204** decodes the PAID field. Continuing to **706**, the processor **204** determines whether the PAID field has a value indicating that an undecoded portion of the SIGNAL unit **520** is to be decoded. At **708**, the processor **204** decodes the SIGNAL unit **520** if the value of the PAID field has a value indicating that the SIGNAL unit **520** is to be decoded. At **710**, the processor **204** defers for a time if the value of the PAID field does not have a value indicating that the SIGNAL unit **520** is to be decoded.

In at least some embodiments discussed above, the SIGNAL units **520** are coded using a convolutional code, and tail bits are included in the SIGNAL units **520**. The tail bits may be all zeros, as in a "zero-tail code," and are used to return the encoder to the zero state, such that the decoding process at the receiver can be initiated from the zero state. By adding the tail bits to the end of each SIGNAL unit **520**, the encoder is returned to the zero state before every SIGNAL unit **520**. Thus, each SIGNAL unit **520** may be encoded separately from every other SIGNAL unit **520** by re-initialization of the encoder before every SIGNAL unit **520**. The independently encoded SIGNAL units **520** may also be modulated independently. Further, both the start and end states of the encoder are known to a decoder used to decode the SIGNAL unit **520**. As such, each SIGNAL unit **520** may be decoded and, in some cases, demodulated separately from each other SIGNAL unit **520**.

In some embodiments, the SIGNAL unit **520** can be transmitted as a short block code. For example, any of the embodiments discussed herein may be transmitted as a short block code. Accordingly, in some embodiments, the SIGNAL unit **520** has no tail bits (referred to as "tail biting"). For example, SIGNAL unit **520** may be the same as any of the other embodiments discussed herein except for having no tail bits. For example, any of the embodiments discussed with reference to Tables 1-28 may be transmitted as a short block code without the tail bits.

The SIGNAL unit **520** may be encoded as a linear block code or a short block code using, for example, an extended Hamming code, such as an (8, 4, 4) rate ½ extended Hamming code. The SIGNAL unit **520** may be encoded as a short block code using, for example, an extended Golay code, such as a (24, 12, 8) rate ½ extended Golay code. The SIGNAL unit **520** may be encoded as a short block code using, for example, a quadratic-residue (QR) code, such as a (48, 24, 12) rate ½ QR code. The SIGNAL unit **520** may be encoded as a short block code using, for example, a tail biting convolution code (TBCC), such as a TBCC code discussed below.

When tail biting is used, no tail bits are included in the SIGNAL unit **520**. Rather, the last, e.g., "n" bits (where "n" is representative of a predetermined number of bits), of the SIGNAL unit **520** are used to initialize the encoder, making the start and end states of the encoder identical, but not necessarily zero. By using the last "n" bits of the SIGNAL unit **520** to initialize the encoder, each field or sub-field of the SIGNAL unit **520** may be encoded separately from every other field or sub-field by cyclically applying convolutional coding to each field or sub-field. The independently encoded fields or sub-fields may also be modulated independently. With tail biting encoding, the decoder knows that the start and end states of the encoder are identical but does not know what those states are. Thus, the decoder must be able to determine the start and end states in order to decode the field or sub-field, for example, by applying convolutional decoding on a repetition of the received field or sub-field. A decoder may be able to determine the start and end states of the fields or sub-fields from information provided in the preamble. As such, each field or sub-field may be decoded and, in some cases, demodulated separately from each other field or sub-field in the SIGNAL unit **520**. When tail biting is used, a CRC may also be added to each field or sub-field, such that determination may be made as to whether each field or sub-field has been decoded successfully, independently of each other field or sub-field in the SIGNAL unit **520**. The encoding process may result in a sequence of code symbols for each field or sub-field that may be blocked together and mapped to a signal constellation to produce one or more modulation symbols for each field or sub-field.

FIG. **8** shows a flow chart of an aspect of an exemplary method **800** of generating and transmitting a data unit. The method **800** may be used to generate any of the data units and SIGNAL units **520** described above. The data units may be generated at either the AP **104** or the STA **106** and transmitted to another node in the wireless network. Although the method **800** is described below with respect to elements of the wireless device **202***a* (FIG. **3**), those having ordinary skill in the art will appreciate that other components may be used to implement one or more of the steps described herein. Although steps may be described as occurring in a certain order, the steps can be reordered, steps can be omitted, and/or additional steps can be added.

At **802**, the processor **204** generates a SIGNAL unit **520**. The SIGNAL unit **520** includes at least a length field and one or more additional fields. For example, the SIGNAL unit **520**

can include one or more of the fields shown above in Tables 1-28. A first field of the one or more additional fields can include an exceptional value indicative of a zero-length payload. As discussed above, an exceptional value can include a field value outside the normal bounds of operation. In an embodiment, the modulator **302** may modulate a transmission that includes the SIGNAL unit **520**, and the transform module **304** may translate tones corresponding to the SIGNAL unit **520** into the time domain. At **804**, the transmitter **210** transmits a data unit including the SIGNAL unit **520** over a wireless channel.

FIG. **9** shows a flow chart of another aspect of an exemplary method **900** of receiving and processing a data unit including a SIGNAL unit **520**. The method **900** may be used to receive any of the data units described above. The packets may be received at either the AP **104** or the STA **106** from another node in the wireless network. Although the method **900** is described below with respect to elements of the wireless device **202***b* (FIG. **4**), those having ordinary skill in the art will appreciate that other components may be used to implement one or more of the steps described herein. Although steps may be described as occurring in a certain order, the steps can be reordered, steps can be omitted, and/or additional steps can be added.

At **902**, the receiver **212** receives a SIGNAL unit **520**. The SIGNAL unit **520** includes at least a length field and one or more additional fields. For example, the SIGNAL unit **520** can include one or more of the fields shown above in Tables 1-28. Continuing to **904**, the processor **204** determines whether a first field of the one or more additional fields has an exceptional value indicative of a zero-length payload. As discussed above, an exceptional value can include a field value outside the normal bounds of operation.

Advancing to **906**, the processor **204** decodes the length field based on the determined exceptional value. For example, the MCS field may include the exceptional value of all-ones. The processor **204** may then decode the reserved bits and determine an alternative frame type. For example, the processor **204** may determine an ACK frame type. The processor **204** may then decode the bits in the length field in relation to one or more parameters of the ACK frame.

In a particular embodiment, a device may generate a SIG unit (e.g., the SIGNAL unit **520**) that includes a length field and an aggregation field. For example, the length field may be nine bits long and the aggregation field may be one bit long. Prior to, after, or during generation of the SIG unit, the device may determine whether or not to use aggregated transmission (e.g., A-MPDUs). In a particular embodiment, aggregated transmission may be mandatory for frame sizes greater than or equal to 512 bytes in size, but may be optional for frame sizes less than 512 bytes. In response to determining to use aggregated transmission, the device may set the aggregation field to a first value (e.g., "1") and may set the length field to a number of symbols. In response to determining not to use aggregated transmission, the device may set the aggregation field to a second value (e.g., "0") and may set the length field to a number of bytes. The device may transmit the SIG unit via a wireless network (a sub-1 GHz network in compliance with an IEEE 802.11ah protocol). The SIG unit may be included in a preamble of a frame, such as a single user (SU) or multi user (MU) frame.

In a particular embodiment, a device may receive a SIG unit (e.g., the SIGNAL unit **520**) that includes length field and an aggregation field. The device may interpret the length field as a number of symbols in response to determining that the aggregation field has a first value (e.g., "1"). The device may interpret the length field as a number of bytes in response to determining that the aggregation field has second value (e.g., "1".

In another particular embodiment, the device may initially determine whether the frame including the SIG unit is associated with 1 MHz bandwidth. If the frame is associated with the 1 MHz bandwidth, the device may interpret the length field as a number of bytes or a number of symbols based on the value of the aggregation field, as described above. However, if the frame is not associated with the 1 MHz bandwidth, the device may determine whether the frame has a short format preamble or a long format preamble (e.g., by checking a rotation of the SIG unit). If the frame has the short format preamble, the device may interpret the length field as a number of bytes or a number of symbols based on the value of the aggregation field, as described above. Conversely, if the frame has the long format preamble, the device may determine whether the frame is a SU frame or a MU frame (e.g., by checking an SU/MU field). If the frame is a SU frame, the device may interpret the length field as a number of bytes or a number of symbols based on the value of the aggregation field, as described above. If the frame is a MU frame, the device may automatically interpret the length field as a number of symbols (e.g., because a wireless protocol or standard, such as IEEE 802.11ah, may mandate that the length of a MU frame having a long format preamble be represented as a number of symbols).

FIG. **10** is a functional block diagram of another exemplary wireless device **1000** that may be employed in accordance with the present disclosure. The device **1000** includes a generating module **1002** for generating a data unit for wireless transmission. The generating module **1002** may be configured to perform one or more of the functions discussed above with respect to block **602** of FIG. **6** and/or block **802** of FIG. **8**. The generating module **1002** may correspond to one or more of the processor **204** and the DSP **220**. The device **1000** further includes a transmitting module **1004** for wirelessly transmitting the data unit. The transmitting module **1004** may be configured to perform one or more of the functions discussed above with respect to block **604** of FIG. **6** and/or block **804** of FIG. **8**. The transmitting module **1004** may correspond to the transmitter **210**. In a particular embodiment, the data unit may include a SIGNAL unit (e.g., the SIGNAL unit **520**), where a length field of the SIGNAL unit is interpreted based on a value of an aggregation field and/or where a particular field of the SIGNAL unit has a value indicating a zero-length payload.

FIG. **11** is a functional block diagram of yet another exemplary wireless device **1100** that may be employed in accordance with the present disclosure. The device **1100** includes a receiving module **1102** for wirelessly receiving a data unit. The receiving module **1102** may be configured to perform one or more of the functions discussed above with respect to block **702** of FIG. **7** and/or block **902** of FIG. **9**. The receiving module **1102** may correspond to the receiver **212**, and may include the amplifier **401**.

The device **1100** further includes a determining module **1104** for determining various characteristics of the data unit. For example, the determining module **1104** may determine whether a first field of the one or more additional fields has an exceptional value indicative of a zero-length payload. As discussed above, an exceptional value can include a field value outside the normal bounds of operation. As another example, the determining module may determine a PAID field has a value indicating that an undecoded portion of a SIG unit is to be decoded. The determining module **1104** may be configured to perform one or more of the functions discussed

above with respect to block **904** of FIG. **9** and/or block **706** of FIG. **7**. The determining module **1104** may correspond to one or more of the processor **204**, the signal detector **218**, and the DSP **220**.

The device **1100** further includes a decoding module **1106** for decoding data. For example, the decoding module **1106** may decode the length field based on the determined exceptional value. The decoding module **1106** may also decode a PAID field and a SIG unit if a value of the PAID field indicates that the SIG unit is to be decoded. The decoding module **1106** may defer for a time if the value of the PAID field indicates that the SIG unit is not to be decoded. The decoding module **1106** may be configured to perform one or more of the functions discussed above with respect to block **704** of FIG. **7**, block **708** of FIG. **7**, block **710** of FIG. **7**, and/or block **906** of FIG. **9**. The decoding module **1106** may correspond to one or more of the processor **204**, the signal detector **218**, and the DSP **220**, and may include the channel estimator and equalizer **405**.

As used herein, the term "determining" encompasses a wide variety of actions. For example, "determining" may include calculating, computing, processing, deriving, investigating, looking up (e.g., looking up in a table, a database or another data structure), ascertaining and the like. Also, "determining" may include receiving (e.g., receiving information), accessing (e.g., accessing data in a memory) and the like. Also, "determining" may include resolving, selecting, choosing, establishing and the like. Further, a "channel width" as used herein may encompass or may also be referred to as a bandwidth in certain aspects.

As used herein, a phrase referring to "at least one of" a list of items refers to any combination of those items, including single members. As an example, "at least one of: a, b, or c" is intended to cover: only a; only b; only c; a and b; a and c; b and c; and a, b, and c.

The various operations of methods described above may be performed by any suitable means capable of performing the operations, such as various hardware and/or software component(s), circuits, and/or module(s). Generally, any operations illustrated in the Figures may be performed by corresponding functional means capable of performing the operations.

The various illustrative logical blocks, modules and circuits described in connection with the present disclosure may be implemented or performed with a general purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array signal (FPGA) or other programmable logic device (PLD), discrete gate or transistor logic, discrete hardware components or any combination thereof designed to perform the functions described herein. A general purpose processor may be a microprocessor, but in the alternative, the processor may be any commercially available processor, controller, microcontroller or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

In one or more aspects, the functions described may be implemented in hardware, software, firmware, or any combination thereof. If implemented in software, the functions may be stored on or transmitted over as one or more instructions or code on a computer-readable medium. Computer-readable media includes both computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A storage media may be any available media that can be accessed by a computer. By way of example, and not limitation, such computer-readable media can include RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium that can be used to carry or store desired program code in the form of instructions or data structures and that can be accessed by a computer. Also, any connection is properly termed a computer-readable medium. For example, if the software is transmitted from a website, server, or other remote source using a coaxial cable, fiber optic cable, twisted pair, digital subscriber line (DSL), or wireless technologies such as infrared, radio, and microwave, then the coaxial cable, fiber optic cable, twisted pair, DSL, or wireless technologies such as infrared, radio, and microwave are included in the definition of medium. Disk and disc, as used herein, includes compact disc (CD), laser disc, optical disc, digital versatile disc (DVD), floppy disk and blu-ray disc where disks usually reproduce data magnetically, while discs reproduce data optically with lasers. Thus, in some aspects computer-readable medium may include non-transitory computer-readable medium (e.g., tangible media). In addition, in some aspects computer-readable medium may include transitory computer-readable medium (e.g., a signal). Combinations of the above should also be included within the scope of computer-readable media.

The methods disclosed herein include one or more steps or actions for achieving the described method. The method steps and/or actions may be interchanged with one another without departing from the scope of the claims. In other words, unless a specific order of steps or actions is specified, the order and/or use of specific steps and/or actions may be modified without departing from the scope of the claims.

The functions described may be implemented in hardware, software, firmware or any combination thereof. If implemented in software, the functions may be stored as one or more instructions on a computer-readable medium. A storage media may be any available media that can be accessed by a computer. By way of example, and not limitation, such computer-readable media can include RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium that can be used to carry or store desired program code in the form of instructions or data structures and that can be accessed by a computer. Disk and disc, as used herein, include compact disc (CD), laser disc, optical disc, digital versatile disc (DVD), floppy disk, and Blu-ray® disc where disks usually reproduce data magnetically, while discs reproduce data optically with lasers.

Thus, certain aspects may include a computer program product for performing the operations presented herein. For example, such a computer program product may include a computer-readable medium having instructions stored (and/or encoded) thereon, the instructions being executable by one or more processors to perform the operations described herein. For certain aspects, the computer program product may include packaging material.

Software or instructions may also be transmitted over a transmission medium. For example, if the software is transmitted from a website, server, or other remote source using a coaxial cable, fiber optic cable, twisted pair, digital subscriber line (DSL), or wireless technologies such as infrared, radio, and microwave, then the coaxial cable, fiber optic cable, twisted pair, DSL, or wireless technologies such as infrared, radio, and microwave are included in the definition of transmission medium.

Further, it should be appreciated that modules and/or other appropriate means for performing the methods and tech-

niques described herein can be downloaded and/or otherwise obtained by a user terminal and/or base station as applicable. For example, such a device can be coupled to a server to facilitate the transfer of means for performing the methods described herein. Alternatively, various methods described herein can be provided via storage means (e.g., RAM, ROM, a physical storage medium such as a compact disc (CD) or floppy disk, etc.), such that a user terminal and/or base station can obtain the various methods upon coupling or providing the storage means to the device. Moreover, any other suitable technique for providing the methods and techniques described herein to a device can be utilized.

It is to be understood that the claims are not limited to the precise configuration and components illustrated above. Various modifications, changes and variations may be made in the arrangement, operation and details of the methods and apparatus described above without departing from the scope of the claims.

While the foregoing is directed to aspects of the present disclosure, other and further aspects of the disclosure may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

What is claimed is:

1. A method comprising:

receiving, at a first wireless device from a second wireless device, a first packet comprising a first signal (SIG) unit, the first SIG unit comprising a first field, the first wireless device and the second wireless device associated with an orthogonal frequency-division multiplexing (OFDM) system;

determining whether the first field has a particular value that is indicative of a zero-length payload;

conditioned on the first field having the particular value:

determining whether the first packet comprises an acknowledgement (ACK) represented entirely by physical layer (PHY) data; and

decoding a second field of the first SIG unit based at least in part on the determination that the first field has the particular value, the second field distinct from the first field; and

receiving, at the first wireless device from the second wireless device, a second packet comprising a second SIG unit, the second SIG unit comprising the first field that has a second value, and the second SIG unit further comprising a partial association identifier (PAID) field.

2. The method of claim **1**, wherein the first field comprises a modulation and coding scheme (MCS) field.

3. The method of claim **1**, wherein the first field comprises a length field.

4. The method of claim **3**, wherein the length field comprises information regarding an ACK frame, a beacon frame, or a link adaptation frame.

5. A method of communicating in an orthogonal frequency-division multiplexing (OFDM) system that includes a first wireless device and a second wireless device, the method comprising:

generating, at the second wireless device, a first packet comprising a first signal (SIG) unit to be transmitted to the first wireless device, wherein the first SIG unit comprises a first field that has a particular value indicating a zero-length payload, wherein the first packet comprises an acknowledgement (ACK) represented entirely by physical layer (PHY) data, the first SIG unit including a second field that is decodable based at least in part on the first field having the particular value, the second field distinct from the first field;

transmitting the first SIG unit to the first wireless device;

generating, at the second wireless device, a second packet comprising a second SIG unit to be transmitted to the first wireless device, the second SIG unit including the first field, the first field of the second SIG unit having a second value, and the second SIG unit further including a partial association identifier (PAID) field; and

transmitting the second SIG unit to the first wireless device.

6. The method of claim **5**, wherein the first field comprises a modulation and coding scheme (MCS) field.

7. The method of claim **5**, wherein the first field comprises a length field.

8. The method of claim **7**, wherein the length field comprises information regarding an ACK frame, a beacon frame, or a link adaptation frame.

9. An apparatus comprising:

an orthogonal frequency-division multiplexing (OFDM) receiver configured to receive a first packet comprising a first signal (SIG) unit and to receive a second packet comprising a second SIG unit, the first SIG unit comprising a first field that has a particular value, the second SIG unit comprising the first field that has a second value, and the second SIG unit further comprising a partial association identifier (PAID) field; and

a processor configured to:

determine whether the first field has the particular value that is indicative of a zero-length payload;

conditioned on the first field having the particular value, determine whether the first packet comprises an acknowledgement (ACK) represented entirely by physical layer (PHY) data; and

decode a second field of the first SIG unit based at least in part on the determination that the first field has the particular value, the second field distinct from the first field.

10. The apparatus of claim **9**, wherein the first field comprises a modulation and coding schemes (MCS) field.

11. An apparatus comprising:

a processor configured to:

generate, at a second orthogonal frequency-division multiplexing (OFDM) wireless device, a first packet comprising a first signal (SIG) unit to be transmitted to a first OFDM wireless device, wherein the first SIG unit comprises a first field that has a particular value indicating a zero-length payload, wherein the first packet comprises an acknowledgement (ACK) represented entirely by physical layer (PHY) data, the first SIG unit including a second field that is decodable based at least in part on the first field having the particular value, and wherein the second field is distinct from the first field; and

generate, at the second OFDM wireless device, a second packet comprising a second SIG unit to be transmitted to the first OFDM wireless device, the second SIG unit including the first field, the first field of the second SIG unit having a second value, and the second SIG unit further including a partial association identifier (PAID) field; and

a transmitter configured to transmit the first SIG unit and the second SIG unit to the first OFDM wireless device.

12. The apparatus of claim **11**, wherein the first field comprises a modulation and coding scheme (MCS) field.

13. An apparatus comprising:

means for receiving, via an orthogonal frequency-division multiplexing (OFDM) system, a first packet comprising a first signal (SIG) unit and a second packet comprising

a second SIG unit, the first SIG unit comprising a first field that has a particular value, the second SIG unit comprising the first field that has a second value, and the second SIG unit further comprising a partial association identifier (PAID) field; and

a processor configured to:

determine whether the first field has the particular value that is indicative of a zero-length payload;

conditioned on the first field having the particular value, determine whether the first packet comprises an acknowledgement (ACK) represented entirely by physical layer (PHY) data; and

decode a second field of the first SIG unit based at least in part on the determination that the first field has the particular value, the second field distinct from the first field.

14. An apparatus comprising:

a processor configured to:

generate, at a second orthogonal frequency-division multiplexing (OFDM) wireless device, a first packet comprising a first signal (SIG) unit to be transmitted to a first OFDM wireless device, wherein the first SIG unit comprises a first field that has a particular value indicating a zero-length payload, wherein the first packet comprises an acknowledgement (ACK) represented entirely by physical layer (PHY) data, the first SIG unit including a second field that is decodable based at least in part on the first field having the particular value, and wherein the second field is distinct from the first field; and

generate, at the second OFDM wireless device, a second packet comprising a second SIG unit to be transmitted to the first OFDM wireless device, the second SIG unit including the first field, the first field of the second SIG unit having a second value, and the second SIG unit further including a partial association identifier (PAID) field; and

means for transmitting the first SIG unit and the second SIG unit to the first OFDM wireless device.

15. A non-transitory computer-readable medium comprising instructions that, when executed by a computer, cause the computer to:

receive, via an orthogonal frequency-division multiplexing (OFDM) system, a first packet comprising a first signal (SIG) unit and a second packet comprising a second SIG unit, the first SIG unit comprising a first field that has a particular value, the second SIG unit comprising the first field that has a second value, and the second SIG unit further comprising a partial association identifier (PAID) field;

determine whether the first field has the particular value that is indicative of a zero-length payload; and

conditioned on the first field having the particular value, determine whether the first packet comprises an acknowledgement (ACK) represented entirely by physical layer (PHY) data; and

decode a second field of the first SIG unit based at least in part on the determination that the first field has the particular value, the second field distinct from the first field.

16. A non-transitory computer-readable medium comprising instructions that, when executed by a computer, cause the computer to:

generate, at a second orthogonal frequency-division multiplexing (OFDM) wireless device, a first packet comprising a first signal (SIG) unit to be transmitted to a first OFDM wireless device, wherein the first SIG unit comprises a first field that has a particular value indicating a zero-length payload, wherein the first packet comprises an acknowledgement (ACK) represented entirely by physical layer (PHY) data, the first SIG unit including a second field that is decodable based at least in part on the first field having the particular value, the second field distinct from the first field;

transmit the first SIG unit to the first OFDM wireless device;

generate, at the second OFDM wireless device, a second packet comprising a second SIG unit to be transmitted to the first OFDM wireless device, the second SIG unit including the first field, the first field of the second SIG unit having a second value, and the second SIG unit further including a partial association identifier (PAID) field; and

transmit the second SIG unit to the first OFDM wireless device.

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